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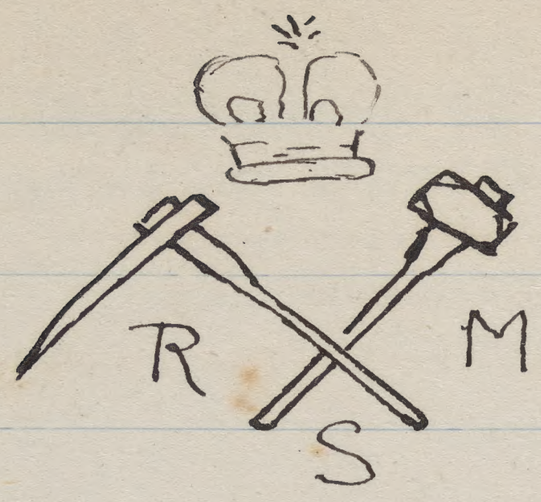

Lectures on

Mining

by

Prof. Warington Smythe.

1880 - 1881

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MSS 1282B RB NMAH

Science and Art Department of the Committee of Council on Education.

A LECTURE ON MINING,

DELIVERED AT THE

SOUTH KENSINGTON MUSEUM,

24th February 1862,

BY

WARINGTON SMYTH, M.A., F.R.S., G.S.

LONDON:
PRINTED BY GEORGE E. EYRE AND WILLIAM SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY,
FOR HER MAJESTY'S STATIONERY OFFICE.
1873.

Price Twopence.

32860.

LECTURE.

No question can be raised as to the paramount importance of the production of minerals to Great Britain. The total value of the metals and non-metallic minerals raised annually in the United Kingdom is estimated at upwards of 40,000,000*l.* A population of between 400,000 and 500,000 persons is directly employed in their extraction; and if we were to follow up the course of these various mineral substances until they fall into the hands of their respective consumers, we should find the total value so enormously increased that we should need no further proof of the vast amount of labour and gain which is based upon the produce of the mines, and of the large number of our countrymen who derive more or less indirectly their employment from the substances which nature has with a liberal hand distributed through the rock masses of our islands.

Moreover, we must not forget that the great gold discoveries of the last few years, and the constant and increasing enterprises for the working of other minerals in most of our colonies, viewed in connexion with the modern facilities of communication, have all to be taken into account in estimating the importance to the Empire of this widely-spread branch of industry.

Those who are least informed on the subject cannot doubt that with this gigantic production there must be coupled a high degree of art and knowledge amongst the persons to whom it is an occupation; but it requires a very intimate acquaintance with our miners, and their methods of operation, to form a conclusion as to the kind and degree of education which it may be possible or desirable to impart to them. Let us not too hastily conclude that men who have not received an education in the ordinary sense of the word are wanting in a thorough and satisfactory knowledge of a branch of their own craft. Some of the very best among "tributers" and "pitmen"* that I have known have been men without any knowledge of reading or writing, but whose natural acuteness, joined to constant observation during the experience of years, have enabled them to accumulate a store of facts, and a constantly applicable judgment, which may be envied by those who have been brought up more conversant with paper and print. True it is that their views are necessarily limited; they cannot with safety pass out beyond the confines of their own particular department, and in most cases they labour under the disadvantage of neither being able to communicate their experience nor to rise from the position of workmen to that of managers. Whatever is to be done in the way of instruction, heaven forbid that anything should interfere with the efficiency of this excellent class of men. As a workman, in his own division of labour, I believe that our British miner is unrivalled: let us hope that no undue meddling may shake him in that proud position.

But there appears to be no reason why the mining workman should be injured by being placed within reach of instruction in the

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* *Tributers* are the class of miners who are paid according to the amount of ore raised by them in a given time out of a portion of the mine which they take on speculation; *pitmen*, in metallic mines, are those who are employed in the placing of the pumps and other shaft gear.

rudiments of general knowledge. It is only a few weeks ago since Mr. Roebuck, with that common sense and boldness of expression which favourably distinguish him, asserted that the end of popular education, as understood by him, "is to make the human being of a "capacity to enjoy the circumstances by which he is surrounded. "That capacity," he continued, "does not now exist. The poor "labouring man of this country is a mere brute animal as compared "with what he might be. I use hard phrases, no doubt, but I use "them for the purpose of conveying my meaning. What I want "is to make the working man capable of enjoying the great "blessings which nature affords, instead of seeking oblivion, as he "now does, in the pothouse. Supposing that man to be endowed "with a capacity for learning, let him take one of the inspired "books which should be found on every man's table, and let him "look out of his window, and he will see things which an uneducated "man could not see. Do you think that the artist's eye is the eye "merely of a painter, the man who can transfer to paper or canvas "that which he has seen? Believe me, it is no such thing. There "is in the man's mind a capacity, a power of seeing beauty where "you can see nothing but vacancy. He looks upon the fields and "sees their various colouring. He looks from one object to another, "and he delights in all the beauties which nature affords. But "such is not the eye of the uneducated man; he passes through life "with all these bright glories before him, and his eye is dim to all "the magnificence which they afford. I want to give him the "capacity to enjoy all the wonders of human nature in the glory "of the human intellect."

But the object which I have in view in responding to the call made upon me to give this discourse, is not so much the application of general education to the miner, as the teaching of the special subjects which belong to his craft.

Let us ask, first of all, can MINING be taught by lectures or by books? To this I would reply, *Certainly not.* No more than you could teach a man by lectures and books to play the violin like Vieuxtemps, or to walk the tight-rope like Blondin, or to paint animals like Sir Edwin Landseer. Nothing but a long and laboriously acquired experience can teach a man the practice of an art. One person will doubtless have a much greater natural aptitude than another, may acquire such experience in an infinitely shorter time, and may carry his art to a far higher point than can be attained by his rivals or imitators. But in all cases actual personal labour is indispensable, and no amount of training can replace the necessity of frequent and long-continued contact with the material object to be worked upon.

Let us, however, avoid being misled by a word. We may give lectures on mining, but cannot teach the practice of the art; and those students who should pass a satisfactory examination in what they have heard and read about, are not thereby qualified to act as miners. We want in the English language some such word as those which are employed for the subject as taught in the German mining schools—*Bergbaukunst*, the art of the working of mines, or *Bergbaukunde*, the scientific knowledge of the same. The French in a similar way teach the *Exploitation des Mines*, or the *Art des Mines*; and it is understood by these terms that a subject matter is treated of which places before the learner an accumulation of observed facts and deductions from sundry sciences, all of which are essential as branches of mining knowledge, but which, if ever so well acquired, cannot form a miner. It should therefore be acknowledged at once,

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as a fundamental point, and to prevent misunderstanding, that it can only be attempted to teach in schools *certain things about mining*, and *not mining itself*.

The art of mining, perhaps, beyond all others, is that which, from the nature of the subjects involved in it, demands constant practical attention, to be closed at no special period of life and no particular term of apprenticeship. The oldest and most observant miner will confess that he daily has something to learn, either some new phenomenon of nature, or some ramification from his own pursuit to one or other of the kindred arts and sciences.

But is mining, then, to be left entirely to the personal experience of the individual? Is it to be abandoned only to that Practice which we know to be the best teacher within a small sphere, but which, when we get beyond the circumference of that sphere, we often see to become rash and unpractical? The fairest answer that can be given to such a question is, perhaps, leaving our own reasoning out of view, to be found in the frequent suggestions and propositions thrown up from the intermitting fermentation which every now and then brings this subject to the surface in most of our chief mining districts. I need say nothing of the numerous continental schools established for the special teaching of the subjects suitable to the mining classes, because the position of the Government, as holder and lessor of the minerals on the part of the public in those countries, renders it needful there to make provision for the education of a branch of the public service. But in England, notwithstanding the minerals have ceased to be considered the property of the nation at large, the subject of mining schools has long been mooted. Numerously signed memorials led our Government in 1851 to institute teaching classes in Jermyn Street in connexion with the already long-established Geological Survey of the country, and the Museum illustrating its mineral resources. Before this an abortive attempt had been made, chiefly through the liberality of Sir C. Lemon, Bart., to institute a technical school in Cornwall. This has been since repeated at Truro, without success, and a third institution for teaching is now, under an altered form, on trial. At Bristol, at Wigan, and at Glasgow similar schools have been opened for some years, but have had to rely on the exertions of a small circle of liberal patrons, and cannot be said to have attained the success which might be expected. Newcastle and Birmingham have repeatedly agitated the question, and have even inaugurated courses of lectures, without having hitherto succeeded in the establishment of permanent schools. And during these years of more or less spasmodic efforts, we have had the turgid bursts of eloquence in favour of industrial training which accompanied the success of the Great Exhibition, when nothing less than colleges and universities would satisfy the enthusiasm of the press; we have read year after year the more sober recommendations of mining schools by the Government inspectors of coal mines, all of them men taken from the practice of the profession; and have heard the advantages of such a system formally put forward by Parliamentary Committees, and dwelt upon by several of the most eminent of the colliery viewers. I fear that we can look upon the result only as a failure; and the reason that I refer to so unsatisfactory a page of history is, that we may search out the causes, and may draw the inference that any attempt at teaching must be so framed as, if possible, to meet the objections which may fairly be urged against any method not founded on the true requirements of the case. It looks at first sight very well, when some terrible catastrophe occurs, that members of Parliament in the House, and editors of papers in their

"leaders," should advocate a higher culture, and insist that all managers should be subjected to an examination akin to that which has been established for the merchant navy. The subject is so extensive, the field of operation so vast, and our condition with respect to such a system so backward, that, persuaded as we may be that some of these requirements ought to be fulfilled, we cannot but feel that many a patient and slow step has to be taken before we can advance to such a regulation.

What, then, are the causes of this want of success? First, there is, with some noble exceptions, the general apathy of the owners and even of the lessees of mineral property. Too commonly they are backward in promoting any change which cannot be proved to introduce an immediate pecuniary advantage. Secondly comes the inherent difficulty of the matter itself, residing partly in the scattered distribution of the mining population, and partly in the nature of the subjects to be taught, and the small supply of persons qualified to teach them. Thirdly, the jealousy, very strong in certain districts, of the practical managers of mines. This jealousy is of two kinds,—the one personal, interested, and therefore not worthy of serious regard; the other deserving of deep attention, inasmuch as it centres in the fear of book learning being substituted for experience, and mere talkers and writers for good workmen. It is under this last head that those who endeavour to teach in mining schools should exert their judgment and their labour, and from this that they should extract a caution to attempt to teach only that which, in a given district, they can carry out practically and efficiently.

So numerous and so extensive are the details which come into play in mining operations, so fraught with risk to pecuniary success, and so momentous in their bearing on human life, that in most cases it will be needful to select only certain portions of the subject which may be more specially applicable to the particular locality.

As much as 300 years ago, when the digging of minerals was, in many of our European countries, conducted on a rude enough footing, the learned writer Agricola had a clear perception of the various branches of knowledge which ought to be acquired by an accomplished miner. First, he should be familiar with philosophy, including therein our modern chemistry, mineralogy, and geology, that he may fully observe and understand the nature and relations of the materials upon which he has to work. Secondly, with medicine, that he may cope with the diseases and accidents to which miners are especially subject. Thirdly, with astronomy, that he may carry out scientific surveys. Fourthly, with mensuration or geometry, that he may deal with the various problems of underground plans and sections. Next, with calculation, that he may estimate and keep due accounts of the expense of machines and of the men's labour. Then, with construction, that he may fabricate, or, at the least, explain to others how to fabricate machinery and buildings. Also with drawing, that he may execute designs of his engines; and, lastly, with mining law, that he may keep from getting into difficulty with others, and prevent his neighbours from taking advantage of himself.*

At the present day we should assert that the sciences upon which the art of mining rests are mineralogy, geology, physics, and mechanics. If these sciences are duly acquired, we have mastered

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* Agricola, de Re Metallicâ. Basle, 1561.

the scientific principles of mining; and these branches, or, at all events, a tolerably satisfactory outline of them, ought to be attainable by many a teacher. But after this preparation comes the practical application of the principles, which can only be very partially acquired from mere teaching; and then the thousand and one modifications and variations of practice, to cope with which nothing less than personal familiarity will suffice, and to carry out which with any degree of perfection years of experience are indispensable.

The particulars of and reasoning about the operations which are conducted on so grand a scale beneath the surface in this our country are, to the majority of the public, very obscure, and require for their illustration some reference to or comparison with other pursuits. Thus, the art of the sailor—composed of seamanship and navigation—rests on the basis of mathematics, astronomy, and mechanics. These are the sciences which an accomplished sailor will have studied in full, whilst an ordinary mariner may only have picked up a few disconnected scraps of one or the other, either by partial study or by communication with others; but both classes of seamen will need a certain amount of experience in the application of these principles before they are qualified to do their duty under trying circumstances; yet the man who has systematically studied the groundwork of his subject will probably require a much shorter time for the acquisition of a given amount of experience than the other, who works by the rule of thumb, or by mere empiricism. So far is this generally allowed, that all aspirants to the command of a ship have now to be tested for a satisfactory acquaintance with the scientific principles of their art.

It would certainly appear that a similar test and similar studies are at least as much needed for the mining body, when we take into account the vast outlays and the number of human lives which are jeopardized by inefficient management.

I would not refer to that recent terrible calamity at the New Hartley colliery, which has excited the sympathy of the entire country, but that a retrospect of the conditions of the case may place before my hearers in a clearer light the number of details which, even under one set of conditions, present themselves for the careful weighing and selection of the miner, and the degree of importance which may attach even to small minutiæ.

I represent on the black-board a section of the shaft of this unfortunate colliery, and the circumstances of the catastrophe will be sufficiently fresh in your minds to enable you to appreciate the serious character of the responsibility attached to the choice of method, under all the following heads, which I will but briefly enunciate:—

First of all, the selection of the best spot for the shaft, and whether one or more should be sunk, or whether access and egress could be obtained in case of accident by means of other workings.

Next, the placing of the pumping engine, and its form, whether the ordinary beam engine or a *bull* or direct acting engine. The material of the beam, whether cast or wrought iron. If the former, it appears to be a question what is the best section for large castings; whether the cooling at unequal rates of the various parts of a beam of the ordinary form does not introduce an undue strain or tension. The form and mode of fixing the axle of the beam, whether square, octagonal, or circular, and how wedged and keyed against the castings. The effect of changes of temperature on the beam, as well from external causes as from the heating of the axle. The

wearing out of the brasses under the gudgeons, and the effect of concussion on the beam by letting it fall a few inches during the change of brasses. The propriety of a cap-piece *over* the gudgeons to prevent the beam from springing up out of its place.

Then, among the other causes which may have conduced to accident :—The pumps, how should they have been arranged? how many bucket-lifts and how many plungers? Was it not objectionable to have one bucket-lift on the cylinder end of the beam? The fracture of the rod or spear (which upwards was 14 inches square, Memel timber) appears likely to have been a primary cause. Thence arise questions as to its material; as to the possible jamming of the bucket in the working barrel, or the plugging up of the snore holes or apertures of the wind-bore, or the concussion given by what is technically called "working on air."

But farther than this arise considerations with respect to the original securing and subsequent maintenance of the sides of the shaft. The original timbering, consisting of $4\frac{1}{2}$-inch cribs and $1\frac{1}{4}$-inch batten planks; was it adequately strong? and ought it not to have been replaced by stone or brick walling? The brattice, again, or wooden division of the shaft, was of a very slight and easily damaged construction; if it had been of solid timber or of stone, would it have been able to resist the accidents to which the lighter wooden brattices are subject? Moreover, in case of fracture of the pump rods or spears, what precautions may be taken for not only preventing their fall downwards, but the violent ascent of the upper part towards the surface? For these purposes all the heavy pit-work in Cornwall is fitted with *out-door* and *in-door* "catches."

It will readily be seen that upon any one of these questions might depend the safety of the whole of the company of a mine, and that a more fortunate solution of even one of them might possibly have either entirely prevented the catastrophe which destroyed 204 valuable lives, or might have led to the rescue of the 199 who were immured alive in that sombre grave.

From a single illustration of this kind it may be gathered how important, if it is to be done at all, is correctness in the teaching of details, how mischievous,—I may perhaps say flagitious,—the undertaking to teach on any other than sound grounds.

This side, indeed, of the subject may advantageously be always present to the eye of the teacher in a mining district. The careful elucidation of the causes of accidents which have occurred may often lead to the prevention of those forms of misfortune in future. Humanity may here interest herself in the work of the teacher, and may from him receive the caution of adhering to the sober possibility of gradually improving the safety of the miner, rather than yield to the temptation of looking with credulous gaze on the Utopian prospects of the unpractical enthusiast. When, on such occasions as that above referred to, some self-satisfied schemer stands forth and announces that he has discovered a plan for entirely preventing all accidents in mines, we can but regret his mingled ignorance and under-valuation of the works of those energetic men who for so many years, as managers, or captains, or viewers, have laboured at the subject, each to contribute his mite, in waging the contest against inevitable difficulties.

A dangerous, probably by far the most dangerous of all avocations, is that of the miner. Let us alleviate that danger, or, at the least, endeavour to prevent its increasing with the increasing depth of our mines, by taking a warning from every well-investigated accident; and, fortunately, the teacher and student are supplied with a

most instructive series of records, in the Reports of the Committees of the House of Commons and Lords, and of Her Majesty's Inspectors of Mines to the Home Office. These useful volumes, including a vast amount of evidence in every branch of coal mining, may be particularly recommended to those who desire to learn what are the practical aims and objects to be most looked to in the selection and treatment of safety lamps, in the systems of working or laying out mines, the various methods of ventilation, and the means of guarding against accidents in shafts.

The single fact that nearly 1,000 lives are annually lost in our coal mines alone, to say nothing of the numerous cases of injury not immediately followed by death, is sufficient to indicate at once the hazardous nature of the employment, and the value of such a system of instruction as may have special reference to the chief sources of risk.

In our metalliferous mines wholesale loss of life is happily unfrequent, but, on the other hand, it is so generally allowed that the men working in them are exposed to influences of several kinds, which materially tend to produce disease and to bring about premature death, that although I may abstain from giving any statistics (believing that some of the evils have been much exaggerated), it is obvious that many of the same considerations will apply also to this large class of our underground operatives.

But it is by no means an easy matter to determine how the different classes of persons employed in mines are to have a technical education rendered accessible, nor at what age it would most profitably be offered to them. In most districts it is much to be desired that actual underground work, perhaps on a limited scale, should be continued through a part of the period. Commonly, too, it would be well that students, before attending a course of general instruction, should have obtained some little experience of mining matters, in order that they may the better appreciate what is to be systematically laid before them; and the whole subject will have to be very differently treated according to the preparation of pupils and the length of time they can apply to schooling. Thus, as the sons of workmen will, in most instances, have but a limited time, and, as their requirements would be within comparatively narrow bounds, the course should include as little as possible besides what admits of direct application. Some of the leading facts and principles of geology and mineralogy, as bearing on the mineral repositories of the district, illustrated by specimens and visits to interesting spots; the chemistry of the gases, elucidated by experiment, especially what relates to the invisible enemies with which the miner has to contend, "bad" air, carbonic acid, carbonic oxide, carburetted hydrogen, sulphuretted hydrogen; then, based on these, the properties of the safety gauze of Sir Humphrey Davy, and its application to safety lamps; the construction and principles of the various lamps in use, the Davy, Stephenson, Clanny, Mueseler, Boty, &c.; and, above all, the conditions under which they remain safe, and beyond which they may become a source of danger. Then the strength of materials, the principles of mechanics, and their application to mining machinery, and to the securing of ground against falls. Lastly, the requirements and value of strict rules and discipline in relation to the safety of blasting operations, propping, carrying of lights, and ventilating arrangements; and these latter may be illustrated by examples as well of great accidents which have resulted from infraction of rules, as of several remarkable cases on record in which perfect safety has been attained under most threaten-

ing circumstances. Such are, *e.g.*, the great and sudden discharges of gas at Walker colliery in 1846 recorded in the "Reports" for 1847, page 49, and at the Oaks colliery, Barnsley, described in the Lectures delivered at the Bristol Mining School, 1857, page 130.

When the pupils comprise those who may ultimately aspire to take the partial or entire management of mines, the course will necessarily have to be greatly enlarged. There must then be no trifling with the sciences; no picking out of a bit here and there because it may be thought specially useful, whilst neglecting the rest. Scientific training would fall to the ground, a failure and disgrace to its projectors, were the object and method of science so misunderstood. In this case, too, the evil results of omissions or blunders may be magnified a hundredfold. It may matter comparatively little whether a score of workmen are more or less instructed in a particular portion of the subject, but very serious is the responsibility when the student is one who may have the welfare and lives of 100 or 500 men depending on the principles he has acquired and the skill with which he applies them.

And in the same way let us remember, that a discovery made by the judicious application of capital, or a mine sustained in successful working by the skill and prudence of the manager, may return to the nation a material advantage greater a hundred or a thousand fold than the seed from which it sprung,—a harvest, in fact, far more abundant than can be expected from almost any other branch of knowledge, unless it be chemistry and its allied metallurgy.

As regards the actual working of mines, I may refer to the annual prospectus of the school in Jermyn Street for the enumeration, by way of a brief syllabus, of the heads of what it appears to me most important to teach. It is as follows:—

The purpose of the lectures on the Art of Mining is to impress on students the principles which should form the basis of the various operations of the miner, and to make them acquainted with examples of mining practice, as conducted under different circumstances in this and other countries.

The course will include the following heads:—

I. Detailed discussion of known facts connected with the deposits of the useful minerals; beds, strata, or seams; stream-works; lodes or mineral veins; flats; pipe veins; stock-works; irregular masses; heaves or dislocations, and rules for searching for the dislocated and lost portion of a deposit.

II. Preliminary research, shoading, trenching, costeaning.

III. Boring, as practised with different apparatus, with rods or rope, with various cutting and clearing implements.

IV. Tools employed in mining, in hard and in soft ground; in collieries and in metallic mines; blasting by various methods.

V. Principles of employment of mining labour.

VI. Modes of gaining access to and lighting subterraneous cavities, including a comparison of the various safety lamps.

VII. Levels and shafts, or the main openings to underground works; driving and sinking.

VIII. Means of securing excavations by timbering, masonry, and tubbing; construction of dams.

IX. Exploitation, or the working away of veins and of strata.

X. Carriage or transport of minerals through the underground roads.

XI. Winding or raising in the shafts, with the machinery and apparatus required.

XII. Pumps and pumping engines.

XIII. Ventilation, its principles and practice; natural ventilation; artificial introduction of a moving power; distribution of air through the workings.

XIV. The mechanical preparation or dressing of ores and other minerals.

In addition to the above heads, there is another department of the subject which should, perhaps, generally be taught in mining schools, and in which the great advantage is prominent, that it may, in a comparatively short time, be thoroughly and efficiently imparted to students. I refer to underground surveying or dialling. It is under two points of view that the production of accurate plans and sections attains a high degree of value, 1st, that we may thereby for present purposes obtain a condensed view of all the facts connected with the works and explorations of a mine; 2ndly, that after temporary abandonment of the excavations, we may have data to assist in the further prosecution of workings, and may avoid the destructive and lamentable effects which have too often resulted from either the total want or the inaccuracy of such sources of information.

As long ago as 1797 the importance of a systematic mapping of mines was impressed on the attention of the Literary Society of Newcastle by Mr. Thomas of Denton; and in 1815 Mr. William Chapman, C.E., again dwelt upon the value of such a system for the purpose of diminishing the probability of the recurrence of fatal accidents in collieries, and of prolonging the duration of the coal mines of the United Kingdom.

At the present time few large collieries or metalliferous mines are conducted without the aid of a satisfactory plan, but there are very numerous mines in which this department is much neglected. Moreover, there is generally a want of uniformity in system, an absence of details which should give all the information that can be laid down on paper, a deficiency of surface objects by which the workings can at a future day be referred to their proper position, and (what may sometimes lead to the most fatal errors) a neglect of observation or notice of the *variation* of the magnetic meridian according to which mining plans are almost invariably constructed. It is too often the case, when mines are worked by companies, that the shareholders are so regardless of what does not, as they conceive, lead to immediate gain, that they grudge the moderate sums needful for the employment of properly qualified surveyors, and either wink at the total neglect of plans, or leave them to be carried out by men already sufficiently tasked, or incapable, although they may dial with accuracy, of representing on paper what they have measured. It might be imagined that if not the lessees, at least the lessors, or *lords*, of mining property would feel this so much a question of self-interest, that they would insist on the keeping up of proper plans. Such a covenant is, in fact, introduced into almost every lease; but unless the facility of appreciating thoroughly good maps be more generally diffused, and the means of constructing them be more abundantly taught, there is often a series of difficulties introduced which the most attentive agents, on the part of the lessors, have an up-hill contest in trying to overcome. I may refer on this subject, coupled with a scheme for the registering of such plans, to the pregnant remarks of Mr. Sopwith, in a pamphlet on "The National Importance of preserving Mining Records."*

"Among other causes which have retarded the progress of improvement in mineral plans and sections, as well as other regular

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* Published by Weale, 59, High Holborn, London, 1844.

details of subterranean operations, the speculative and uncertain nature of mining is one of the principal. But mining, though certainly speculative, is not entirely the work of chance: in it, as in all other business, he who classifies his accounts, and can at any time readily ascertain the exact sources of expenditure and income, who derives experience from the constant accumulation of facts, and can comprehend the whole extent and object of subterranean works, possesses very superior advantages over those who have no such data. The well-founded calculations of the one are, in the ordinary course of affairs, much more likely to be attended with success than the vague and unsatisfactory speculations of the others, who (and experience daily testifies to the fact) are often involved in difficulties that might easily have been avoided, and in expenses which need never to have been incurred."

Such are the principal topics under which, as I think, the subject of mining may advantageously be taught. I would never dissociate entirely the art of working collieries from that of working metalliferous mines, since both have much in common, and the one may often profitably borrow an idea from the other. But in the various districts where schools may come to be established, it will be needful to dwell with more force on one department than another, and according to the opportunities of the teacher to select special portions for the more full and practical treatment.

In conclusion, I would impress upon you that the teachers in a mining school must never cease to be students. Every new introduction of apparatus, every freshly noticed natural phenomenon to which they can get access, is to be observed and stored as a treasure. Our mining districts have mostly been very backward in accumulating or recording the experiences of duly qualified observers, but the Mining Institute of the north of England has led the way in a useful course, which has been followed up by South Wales and South Yorkshire, and by the Geological Society of Manchester. In this pursuit, as in other branches of civilization, we ought to be truly the "heirs of all the ages;" and until successive steps are observed and recorded, and the gradual acquisitions of practical men are brought into regular method and system, we can hardly say that we make the most of such our inheritance.

LONDON:
Printed by GEORGE E. EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.
[7498.—500.—10/73.]

Lectures on Mining. Monday 8th November 1880.

I. The subject commands our attention from its very high importance in a commercial point of view, especially in this country and because of its intimate connection with a number of sciences in which we cannot fail to be interested. With regard to its commercial importance we need only look at the very large number of people engaged in our mines, and the enormous sums which represent values of substances raised. Upwards of 134 millions tons of coal are raised annually having a value of about £47, million. and employing half a million of miners.

Of Iron ore 14,000,000 tons of a value of £5,000,000
Of Tin ore 14,600 tons of a value of £600,000
Copper ore. 51,000 tons
Lead ores. 66,000 tons

So the total value would be £60,000,000 in a rough sketch.

The art of mining may be said to comprise those processes by which the useful minerals are obtained from their natural localities, these localities

being generally underground, sometimes actually on the surface, sometimes at great depths below the surface. The art of mining consists in the working of mines. but in all languages there is an ambiguity in the meaning of the word 'mine' 'Metallum' sometimes meant a metal, sometimes the place from which it was obtained.

"Mine" has different meanings in different parts In Lancashire - a seam or bed of coal in Scotland an underground level or gallery driven through the rock from one seam of coal to another: Legally it means "a working in which men have to be lighted at their work by artificial light, so quarries are not included. In South Wales. 'mine' means the ironstone of the coal measures, while in the Forest of Dean; the brown hematite of the district.

Auxiliary sciences. Geology, mineralogy, mechanics and physics, but the application of science can only be properly brought into play by the light of actual experience in the mine.

When at first land was divided among conquerors & their chief officers, the minerals were retained for the service of the great bulk of the people, as represented by their king, hence in some countries traces of this remain, while it has be greatly modified in others the holdings remains unaltered, this may be called the law of royalty In Austria, France, Germany, & Italy, you can not commence working unless you apply to a government officer and have a certain district allotted to you. A person in England can sell the land but reserve to himself the right to enter and work the minerals underlying it, this is especially the case in the western districts. In France the same modification was made until the great revolution, when the right of minerals was again taken up by the government, in such case it is necessary to train a corps of qualified men as at the Ecole des Mines to look after the government minerals. In England a relic of this is seen is the term 'royalty' commonly applied to the proportion of the mineral paid to the owner of the soil - otherwise "dues" duty' 'rent' 'free share' 'dish'.

The great disadvantage of the English system is the limited period for which the land is let. In the gold diggings and mining districts of N. America and Australia, each man staunching he can find something has allotted to him land, 12 ft long, in which to operate. In many old German mines much work was done in shallow workings. A man finding a spot of ground marked it, & had a right to work for a certain distance on each side. The measure was 7 fathoms and this was laid midway across his spot and then 3 measures on each side were allotted him. ("Fundgrube") Then a set of 7 fathoms was marked off for the finder, another for the Queen and so on. In Derbyshire one applies to an officer called a 'barmaster' and claims the right to work in each corner of his piece he places a small wooden structure, intended to represent a windlass, and it is felony to remove that landmark. When the works have to be deeper as in Australia, several men join together, each having so much frontage.

It may be disadvantageous to have too large a set, as the operations cannot be concentrated.

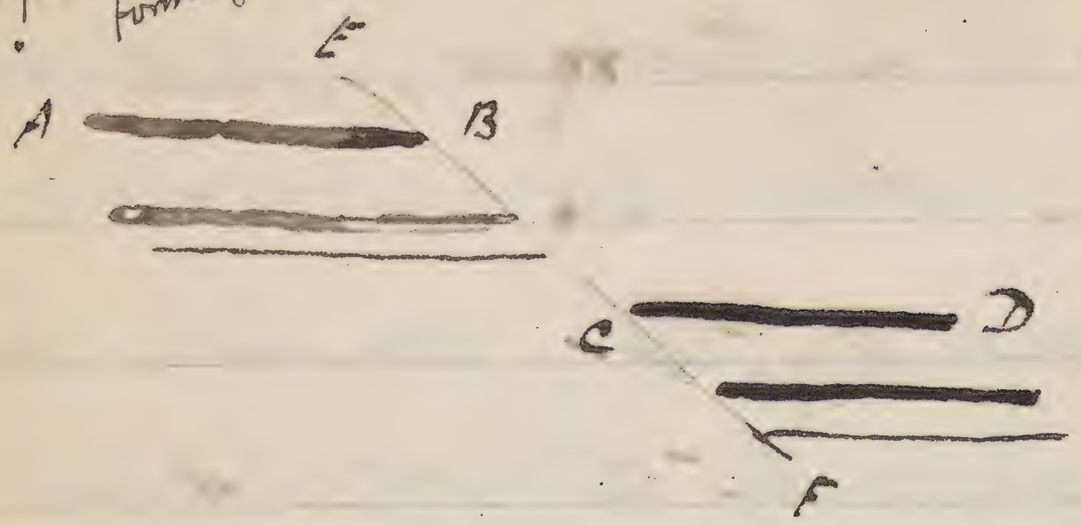
Lecture 2. Tuesday 9th November.

The natural history of the localities in which mineral deposits are found - belongs to subject of geology. Rocks are divided into two great classes.
1. Stratified or sedimentary - in which we have a number of beds or layers - generally it is only a small minority which contain useful minerals.
2. unstratified, massive, or crystalline, have no parallelism of any kind as granite and porphyry. The minerals we work are scattered either in beds more or less horizontal, known in different districts as beds, strata, seams, delfs, sills, meesures, mines, and girdles. Or they form bunches and masses of various kinds, in which their relation to the other

rocks is not so clear or they form deposits which have intersected other rocks after they have solidified
The beds are tilted up to various positions, and we must ascertain the 'direction' to which they dip, and the amount of inclination measured from a horizontal line. Former determined by a compass - magnetic N as. the inclination by a clinometer. For the inclination terms rise and dip are used, but in W. England after fixing on a point on the bed, the direction upwards is called 'to the land, or the rise' that downwards is spoken of as "to the dip".
Notice the direction of the bed, which will be at right angles to the direction of dip, in collieries "water level", geolical term is "strike". The upper boundary of a bed is the 'roof', the lower, the floor sole or (Scot) pavement. The least thickness of a bed of coal workable with advantage cannot be determined as other circumstance have to be considered. 'Ten yd. seam' of Staffordshire is the most valuable

Some beds of lignite reach 100 ft in thickness, while in Somersetshire seams 11 inches thick are worked.
The strata are tilted at various angles, sometimes vertical or, as in Alps, turned over quite to the other side.
In N. of France and in Belgium, often a single vertical shaft has cut one bed of coal 3 or 4 times owing to the zig-zag manner in which the seam has been bent.
Bedded deposits are now used which were at one time looked down upon with contempt. Black band iron ore - used at one time to be thrown away, but now it has rerivified the iron trade of Scotland and happy is the iron master or coal miner who comes across a bed of this.
Frequently the roof is said to come down, you find the seam taken up by a mass of sandstone, this is due to erosion in the original bed while at the surface and subsequent filling up of the valley formed by a deposit of sandstone. Another very important class of interruptions, which belongs to what geologists call a fault, where you come to a

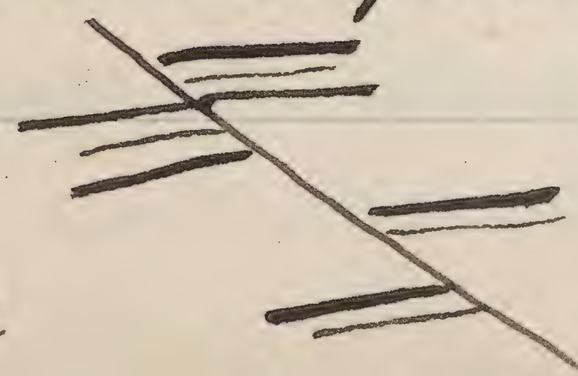
Sometimes the floor will rise up into the seam - forming a "hog's back"



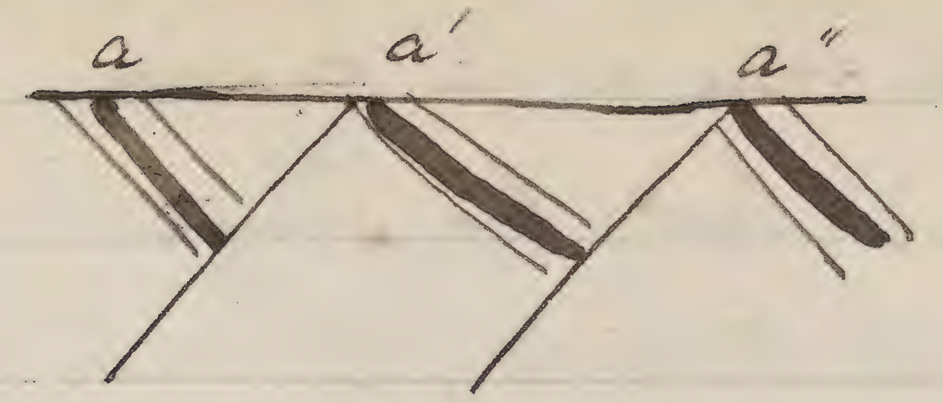
cutting off of the beds, and a displacement of them up or down. This is called by miners a hitch or trouble, if on a larger scale a dyke and to represent the displacement of the beds it will be called a trap up or down, or a throw. It may be a few ft or yards, sometimes 2000 ft. and the line of fault very frequently contains a thin parting of clay or other matter.

There is a rule for ascertaining the ~~amount~~ direction in which to search for the displaced beds, through not the amount. The rule is that if the fault is dipping from you, you have to go downwards. Sometimes a little smut or coal is turned down at the corner, to show in which way the movement has occured, this indication is not constant nor always correct.

Curious exception at Radstock - Somersetshire (Lady Waldegrave's Colliery) where one portion is pushed up over the other 100 - 200 yds.



overlap fault.

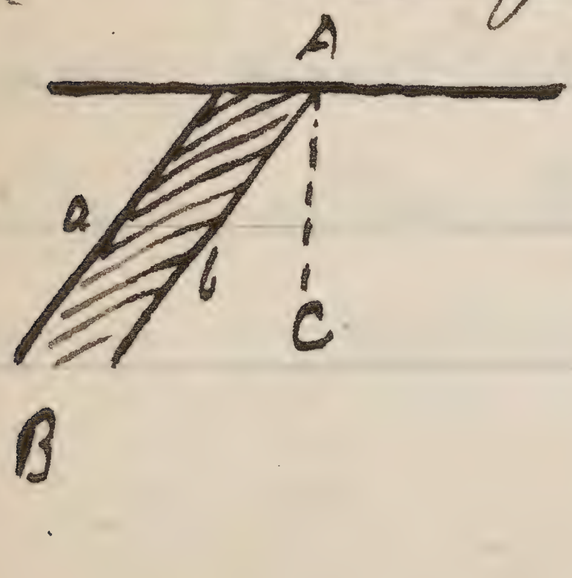


There is one irregularity which needs caution, viz where a series of faults has brought portions of the same bed to the surface several times; and in surveying it too might be taken as so many different beds of coal.

Thursday 11th November 1880

Lecture 3. From veins or lodes a large proportion of the metallic minerals are raised. "Vein" generally 'lode' used in W. districts. Rake vein = those which have a considerable inclination in central & N. England. Vein. French filon Italian filone German gang pl gänge. Often stated that veins are like veins in human body or the branches & twigs of a tree, and people often spend money in digging down, so following small twigs or veins, in hopes of coming to the trunk. Werner, geologist of Freiberg, has been said to have first

put forward the theory that a vein is a fissure filled up with different materials. But Mr Smyth claims the honour for Dr Pryce of Redruth (Mineralogia Cornubiensis)
Lodes are spaces between two walls, more or less parallel, but sometimes deviating from this excessively, running with more or less regularity as to their line of direction and line of dip into the earth.
(Geological Museum. wall cases 24-36)
When the veins are the size of a finger or an arm they are "branches" Still smaller ones are 'strings' (Derby Spar) & such strings are of great importance in Pb & Sn. ore. The presence of a number of these small strings make it work while to work a considerable area of the rock. (= German Stockwerke)
The dip of the lode is the angle between the lode and the horizontal line - The dip = the underlie (or underlay of the miners or 'hade' | and they prefer to measure the angle of inclination from the perpendicular
If you have a lode which in some place



Silver lead lode
Barrystown Ireland.

is almost vertical, in others less so, it is found that the more perpendicular portions will be most productive of ore, and the more inclined parts will be poorer.

The boundary planes of the lode are generally called its walls, the lower = the foot wall, the upper = the hanging wall. (Ger. liegende = Hangende)

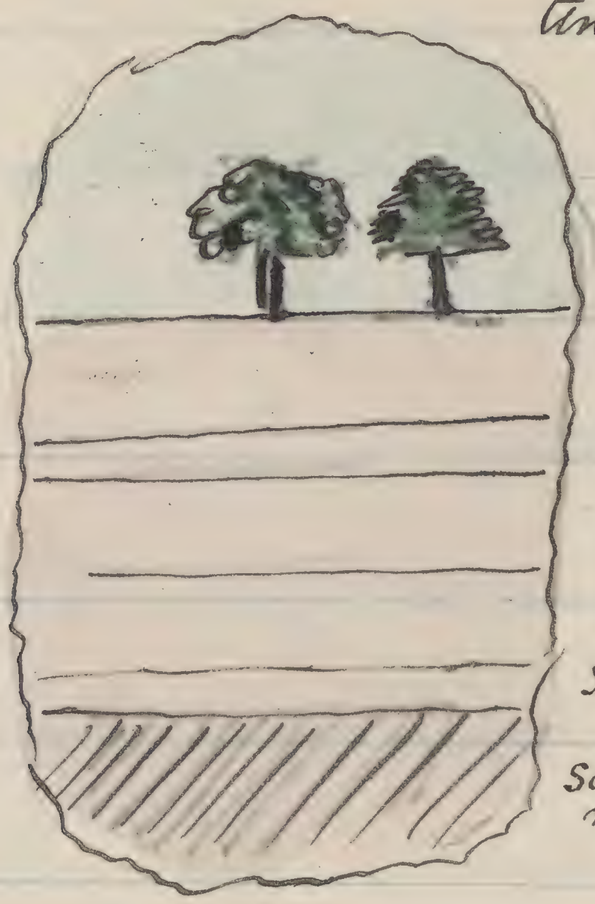
In N. England veins run E. and W. and are checks, North cheek, and (on the S.) the Sun cheek.

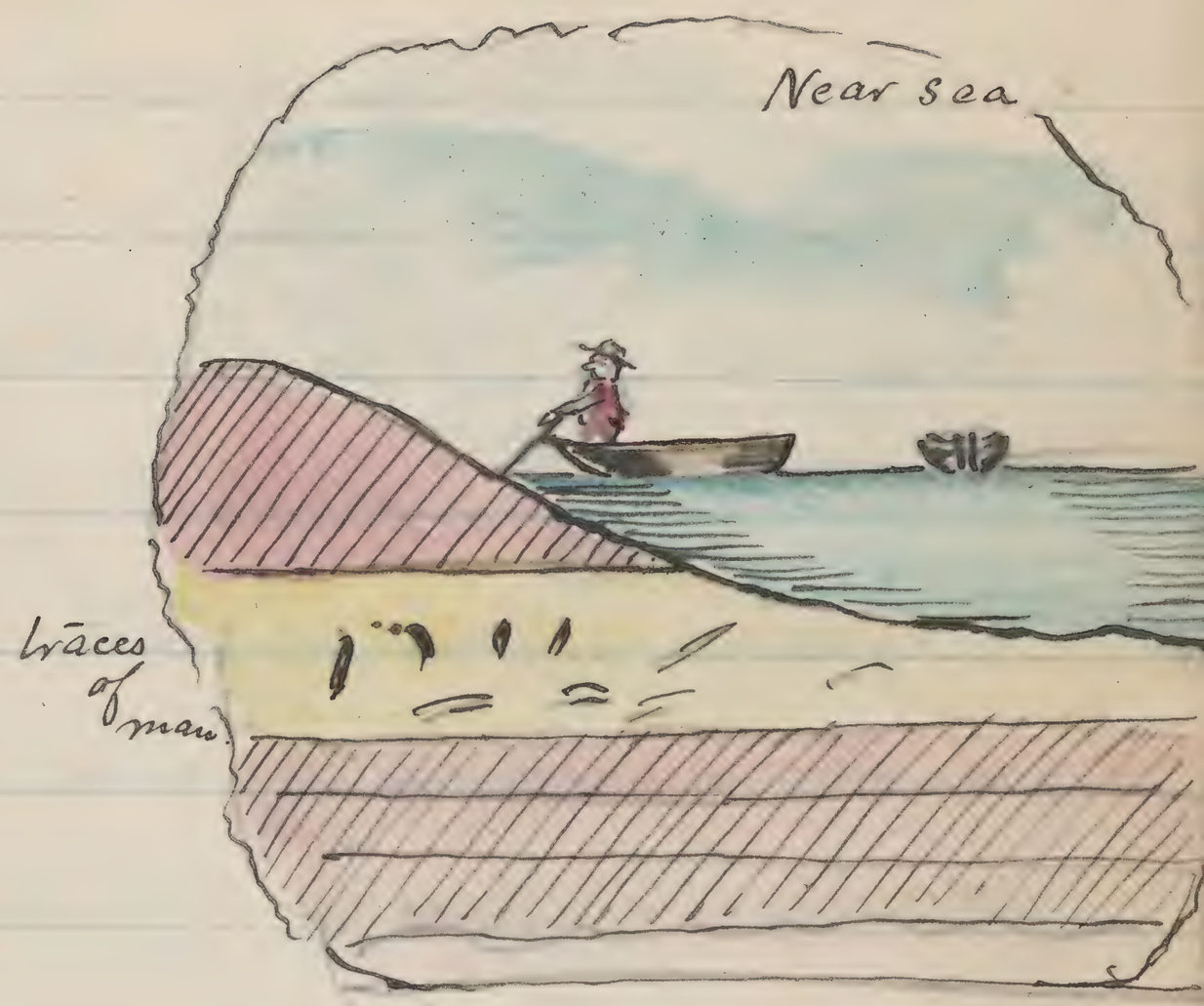
The thickness of the vein is the distance between the walls, sometimes difficult to say which is rock & which is vein. It sometimes happens that on one or both walls, a thin band of clay (flookan) lies between the vein and the rock, which defines the boundary of the vein, & facilitates the removal of the vein stuff, and sometimes determines practicability of working. Great variation in thickness of veins which can be worked. In Derbyshire veins 1,-3 inches thick - depends on rock associated, as, e.g., whether it will powder well under the stamps.

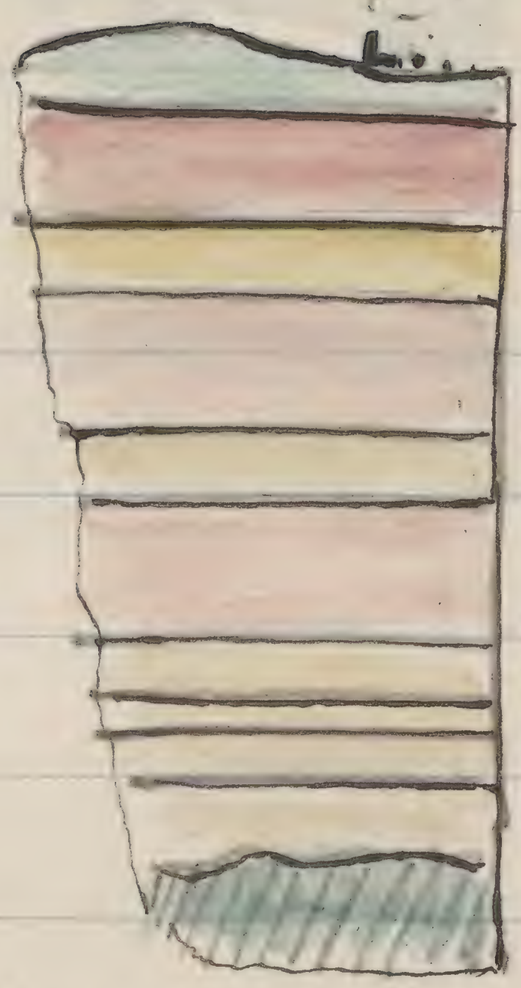
Average thickness, width, or power is 1-6 ft.
In Laxey Mine, Isle of Man, 12-18 ft.
Foxdale Mine. 36 ft (with 30 of workable rock)
Devon Great Consols. 40 ft sometimes.
Schemnitz 120 ft. (Hungary)
Mexico. 140 - Comstock Lode, in Nevada,
200-300 ft from wall to wall. Then they become difficult to work as expensive and elaborate timbering is necessary

'Breccia' a confused mass of angular fragments. There is a hard grey variety of Quartz (Capel) which often constitutes a considerable portion of the tin veins.

Alluvial deposits







White horse Lead
319 ft.

couches. (French.)
lager (German)
flötz (German)
Schechter (German)

Alluvial deposits on
the hill side in Australia
are called 'dry diggings'

Brough-Smythe. Gold Mining in Victoria.
Wallace - Lead veins in Alston Moor
Pryce - Mineralogica Cornubiensis.
Forster - Studies of strata of North of England.
Phillips Manual of Geology.
Farey. Report on Derbyshire.
Henwood - W.J. Vol V and VIII of Transactions
of Geological Survey of Cornwall.
Hayne J.D. Mining industry of 40th parallel.
Whitney - Metal wealth of the United States.
Phillips J.A Mining of Gold and Silver.
De la Beche - Geological report on Cornwall.

Ponson - Burat - André - Callon.
Lottner and Serlo. (Serlo)
Moissenet - Etudes sur les filons de Cornwall 1874.

Friday November 12th 1880.

Lecture 4. Great variety of minerals found in a lode - Phœnix - 16 × 18 different minerals Elie de Beaumont observed 48 out of 64 elements in Dis mines. Masses of ore are 'bunches' if short, if of great length are courses if very irregular all round they are 'sqeals' or pockets (Span. bonanza) If you have a tolerably regular vein it would be a 'short', if extended in height than length "a pipe or short" (U.S. chimney or pay chimney)

The distribution of ore in a lode is extremely irregular and difficult to account for.

Where a lode changes its course materially we may expect to find a difference in quality..

5. There are now a number of mines, being carried to a depth of 300 fathoms, & some few deeper. and one can scarcely point to a single instance in which the bottom of a true lode has ever been reached. A coal mine at Gilby (near Charleston) 3411 ft deep - At Przibram (Bohemia) over 500 fathoms reached this 5 yrs ago. The Samson Mine (Harz) 420 fathoms - Treo-avean Mine (Cornwall) 350 fathoms Fowey Consols 340 - Dolcoath 360. now in granite, having passed from being the richest Cu mine to being the richest Tin mine.
Nevada - 3000 ft. level.
In following down the veins we see that they vary in size and productiveness. Consequently mines are closed or coming to unproductive parts often, and reopened after a time, when labour is cheaper & machinery improved.
In Derbyshire principally in mountain limestone, on following veins down one comes to a band of rock of more or less volcanic character,

"Wadstone" (Ger. 'todt' dead) and this is said to cut off the veins entirely, but further researches have shown that the veins are carried forward through the wadstone, often obliquely ("squinted" in one direction)

In the N. of England — the rocks consist of alternations of beds of blue limestone, of yellowish grit or hazel, and of grey slaty beds, shaley clay. The vein will be found to be richest in the limestone, in a less degree, but still moderately productive in the grit-stone, and then greatly impoverished in the shale, and very often this is accompanied by a slip so that the vein is pinched together, and represented perhaps by only a few strings of calcspar, with mere specks of ore.

In Cornwall and Devon the miners are always very apprehensive when they approach a different kind of rock from that in which they have been working successfully, they fear that

the vein may cease to yield, and this is not
without reason. As a rule Tin is more especially
found in Granite and Cu in slate. Looking
at the Map of Cornwall we see that the
whole of the mining districts are aggregated
within a small belt of ground around these
elevations of granite. Most are at the junction
of the granite and killas. The Cornstock Lode
(St. Agnes) has one wall of dioritic rock,
and the other (a syenitic rock) andesite. porphyrite
The same holds good in the clay slate rocks.
If you have a strong durable rock, very readily
fusile, you are not likely to meet with anything
ore bearing and as you approximate to it you
lose the probability of finding good ore.
On the other hand, if you take a series of
specimens of killas from different productive
districts, they will have pale buff and grey tints
and have a sort of earthy character, often with
a little crystalline structure about them,

which appears as you approach the granite. When you see this, the Cu ore, if present, will be red and black oxides, and carbonates, where as if you follow them into the darker killas the ore often changes into the more common ore — Cu pyrites.

6. In Norway (Kongsberg), the district consists of hard metamorphic slates, which in a N. and S. direction run what are called 'Fahlbands' - a hard quartzose schist with Mica and Hornblende which have generally disseminated through them many sulphides, principally iron pyrites, with Zn blende etc. They can be observed in walking across the country by their ochreous appearance due to the decomposition of the Fe pyrites. Veins run across the country and wherever they pass through the fahlband (E to W) are argentiferous and although of a width of not more than 5 or 6 in. have been followed down to a depth of 266 fathoms, but when they have been followed into the harder schist of the country they produce nothing

Ferruginous masses of red and brown tints have received attention from the miners of all countries from an early period because they are found to cover the valuable deposits of the ore below - 'Gossan' (Cornwall) and a Cornish miner will undertake to distinguish the different kinds of gossan which accompany the different ores. Generally, he would prefer a dark gossan with not too much quartz in it, but of a somewhat friable character.

Gossan = Eisen Hat "the iron hat" german.

"Chapeau de fer" of the French.

In some cases it penetrates to the depth of 40 or 50 fathoms - Generally the gossan decreases as the ore increases, in the Devon great Consols they came down suddenly on a mass of Cu ore 30 ft wide.

Gossan in itself may be a useful mineral Since the surface changes (Haidinger "anogene") are due to air and o

we may expect to find in the gossan only those minerals which can resist such changes. In some case, the precious metals, or silver ore (AgI) or tin ore as in Cornwall As an example of surface changes we have the case where a lode shows brown iron ore at the surface, but at 30 fms gradually changes to chalybite

7. On the continent instead of the points of the compass, the German miners take the clock - when 12 is at N (at Freiberg)

between 12 and 3 (stehendegange)

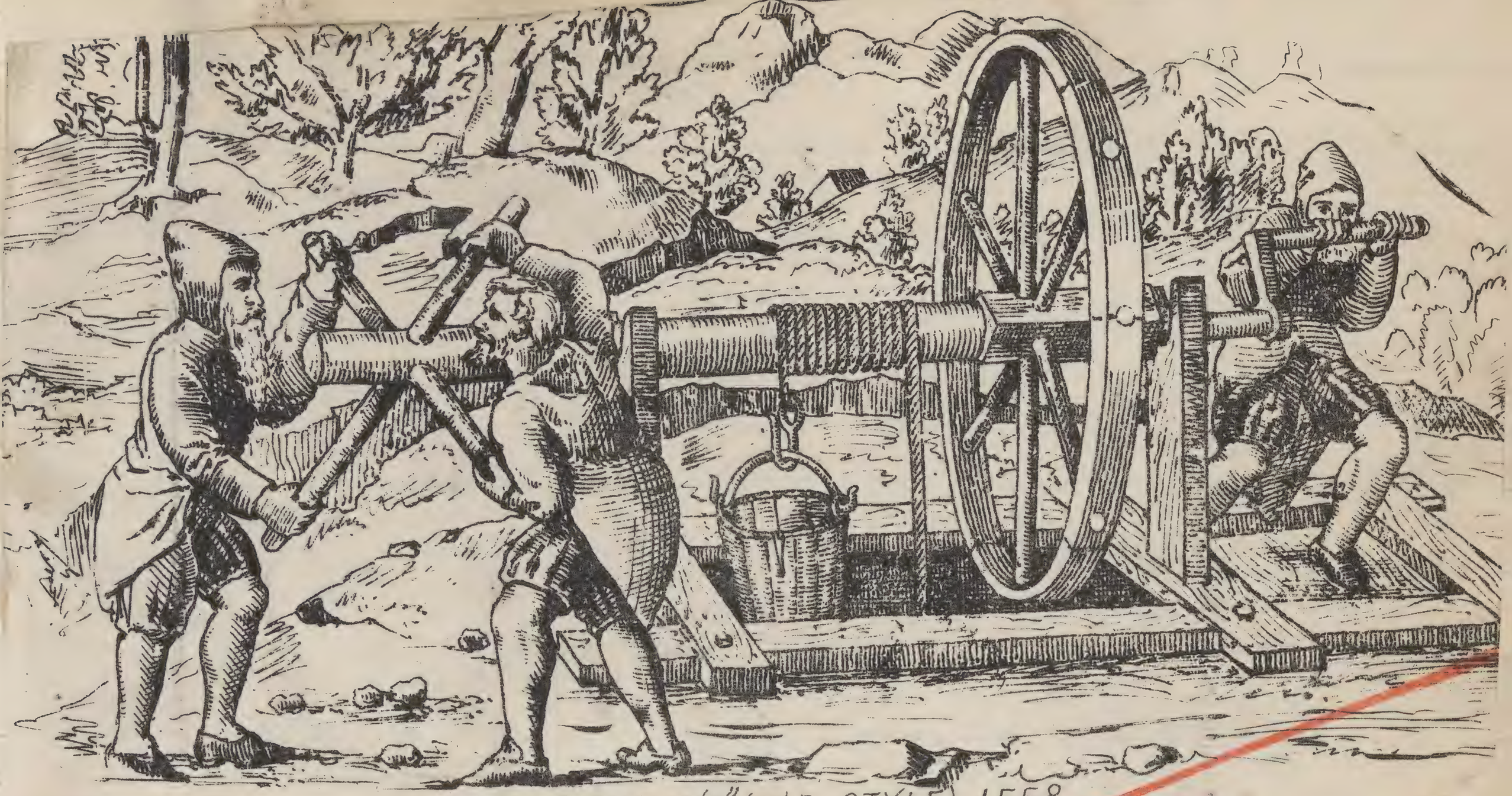
3 and 6 (Morgen gange)

6 and 9 Spat (Spars - Barytes)

9 and 12 Flach (flatter dip)

It has been proposed to divide the Cornish lodes into 8 groups

1. oldest E and W tin lodes with dip to N.
2. E and W tin lodes, dip to S.
3. E and W copper lodes (distinction cannot be carried out,
4. Caunters
5. cross courses
6. includes newer Cu lodes and certain Lead lodes
   (example near St. Agnes Head)
7. cross fluccans
8. slides having E and W course - placed last.



"HAULING" (OLD STYLE) 1558.

PROSPECTING FOR MINERAL, 1558.

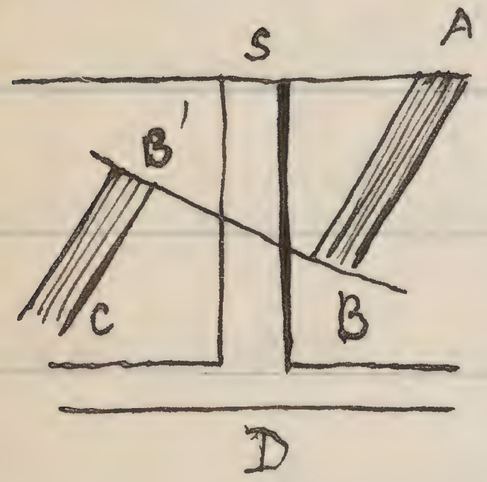
8. With regard to the nature of lodes, we have seen that in the best known districts the lodes are generally well marked in their characters, each series differing from the other in certain points. As exceptional cases we may find veins running in very different directions but nevertheless bearing the same minerals as in Nassau and Siegen. Here there are lodes running a little N of E. and S of W. and others at nearly rt. angles to the first, yet both yield magnificent ores of Fe & Pb. And in the Isle of Man is a fine lode, coursing E & W, and producing Pb rich in Ag - and another equally as good / N. and S. But usually some difference can be noted, as in Siegen and the Isle of Man and Alston Moor. C.f. as a general rule, the N and S lodes are apt to be very bunchy and unequal, (notably the case in Siegen.)

Dislocations or heaves.

Accurate opinions and reasonable hypotheses only brought forward within the last few years - great vagueness even in the last century, which can be traced back as far as the time of Agricola., in the middle ages. Agricola saw that the disturbances were frequent where the lodes do their best, and that ~~in~~ in some cases where the lodes crossed at rt. angles the two were fused together at the point of intersection, in other cases one lode ran right through the other.

More commonly one lode was inclined towards the other, and then it occurred that one of them was disjointed or heaved so that to find the other part of it you must go in a certain, or rather uncertain direction. This displacement may also occur with lodes intersecting at rt. angles. Agricola also saw that if there was a break the lode would be found again on the side of the larger angle. Then a no. of authors (esp. germans) wrote on the subject without making it much clearer, Kept back by the peculiar views on Geology held by Werner's School. Werner (1791) saw that these veins must have been the result of the dislocations of the rock masses. Schmidt (1810) first put forward clear views on the subject, since corroborated in Transactions of R. Geol. Soc. of Cornwall and in publications issued at Freiberg.

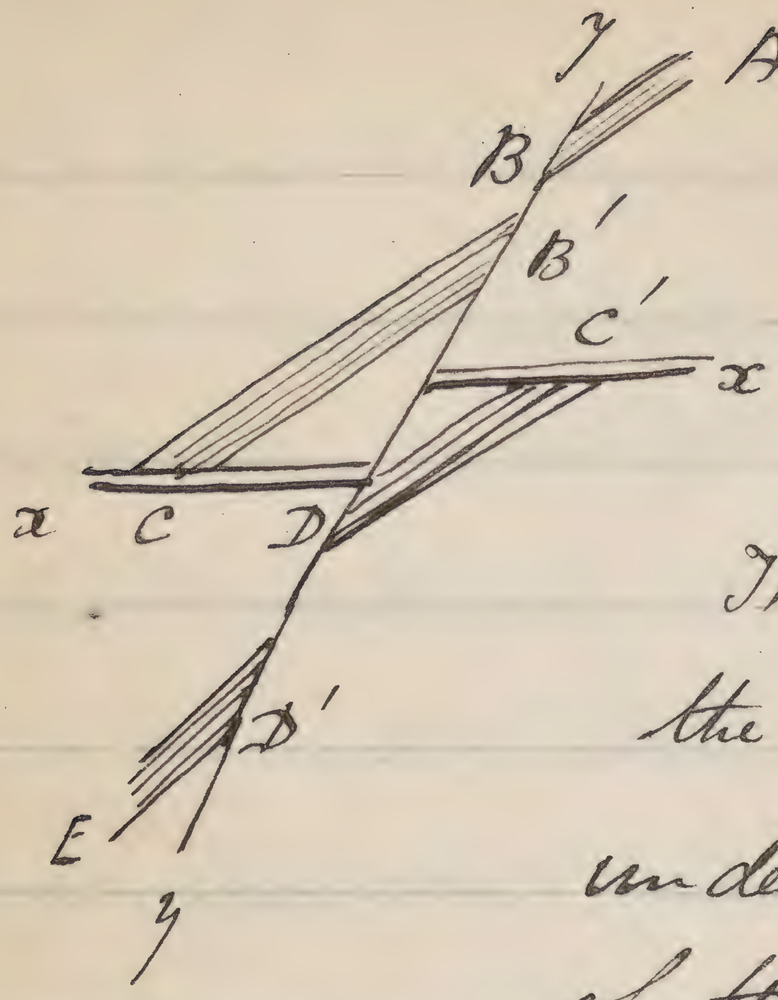
First consider these heaves in a perpendicular then in a horizontal



A case occurred a few years ago at Knockmahon, Waterford. Ireland. A represents a portion of the lode discovered by surface trenching etc. A shaft was sunk (S) for the purpose of intersecting the lode as usual, but they went down for some

distance beyond the point at which they ought to have struck the lode, and could not find it. They had not observed in sinking the shaft a little thread (BB') which passed through it crossing in the same direction as the lode itself but dipping in the opposite direction - This lode was in fact a heave, Shows the necessity for noting carefully every such appearance which looks different from the ordinary joints of the rock. The early miners had a false idea that this sort of dislocation would be produced to a greater extent by a thick mass of hard material, and some even said that the stronger vein in point of hardness would dislocate the other - We may come to the opposite conclusion (Stockan)
The simple mode we have of determining where the continuation of the lode lies is that the broken point of the lode is lower on the side of the hanging wall of the dislocator (fig. where B the lower point of the dislocator is on the side of the hanging wall of the dislocator BB')
In fact, the same rule as in the case of stratified deposits. Exceptions, as in the case of beds, to this rule. When they occur the slide is an extremely flat one.

Rule holds in 49 out of 50 cases.

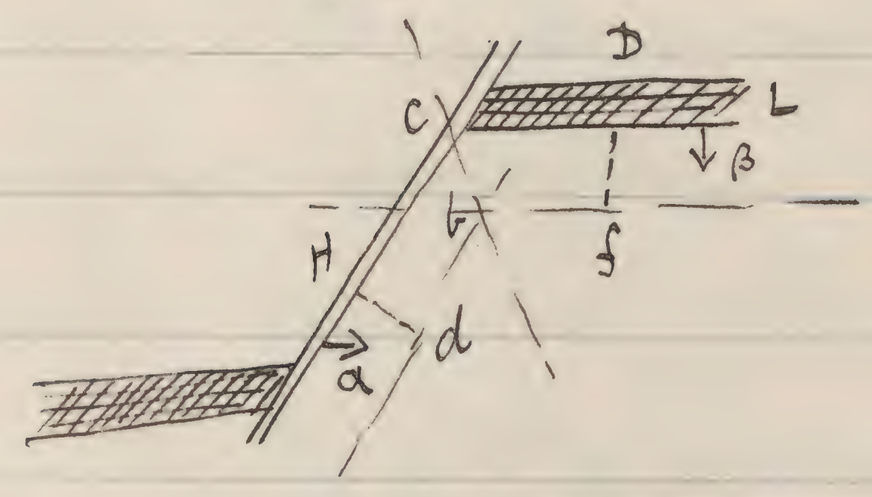


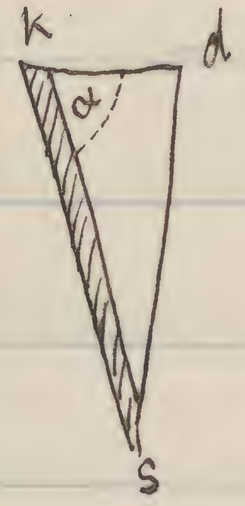
1st This double dislocation occured in a mine on the S. of the Carpathians in Hungary.

The district of St Agnes in Cornwall where the tin lodes are generally very flat in them underlie is one where a great number of these dislocators usually occur, and have the effect of heaving the lode, and there are cases where one lode has been brought to the surface two or three times, these dislocations are locally "gossans". In other districts these are unknown. A cross vein intersecting a lode may displace it only to the breadth of the lode or even less, or it may displace it several feet or fathoms. A complication of these phenomena can be seen at Knockmahon copper mine.

On coming to one of these dislocations the question is which way shall we turn to discover the lost lode. Various rules in various districts, some say always turn to the left, others to the rt., some on the side of the greater angle others on the side of the lesser.

This is because miners in each district have observed what has been the most successful method in their own district. A more finite rule was propounded by Schmidt — (The cross courses receive different names as 'flookan', 'spar courses', 'cross courses' 'trauns' (Lat: trans) and 'guides' because by following them along they serve as guides to meet with veins which come into contact with them. They are filled with clay, quartz, Fe pyrites. The lode on the hanging wall has slipped as it were down the plane; or the relative movement of the sides has been equivalent to that and in the case of an inclined lode this downward movement has the result of shifting the lode horizontally at a given spot, so when a miner comes to the cross course he must determine in which way to work in order to fall in with the same lode again — (Schmidt's rule.





Take the case of a lode L running E and W, and intersected by a cross vein x and let them be laid down as in fig. in our mining plan. We have first to determine the line of intersection of the two planes — the

plane of the lode and that of the cross course. It is important to determine this for two reasons — 1st because we very frequently find it to be a line near or along which a run of rich deposit is likely to be met with, and 2ndly because it helps us to the solution of the prob. For this purpose we must make out the strike and dip of both lode and vein and indicate them on our plan the dip being represented in direction by the arrows. We have already one point in the intersection — C. To determine a 2nd. we draw two lines parallel respectively to the lode and the vein at the same absolute level. Suppose the amount of dip of the cross course to be α degrees, and of the lode β degrees, and if we take h to represent any vertical distance below the position of C at which to draw our levels, then the distance (Kd) at which we must draw our parallel to the vein will be

$$Kd = \frac{h}{\tan \alpha} \quad \text{and the distance } Df = \frac{h}{\tan \beta}$$

For if in next fig. KS represent the dip of the cross course.

making the angle α with the horizontal kd and $ds = h$, that is the depth of the level we have chosen then obviously $kd = \frac{h}{\tan \alpha}$ similarly with Df. If then we draw these parallels, the point of intersection i will be another point in the line of intersection of the planes of the lode and vein, and we can now draw the line of intersection through it and i.

Now comes Schmidt's rule - Strike a perpendicular through the dislocator and on whatever side of the line of intersection that $\perp$ falls it is on that side you must drive. Thus in fig 9 continuing the cutting of the lode through the dislocator and ~~on whichever side of the~~ at C, the perpendicular would fall on the left hand side of the line of intersection, and consequently according to the rule the broken part of the lode will be found on that (left) side, in other words drive away from the line of intersection not through it -

Mr Henwood (5th vol. Trans. Geol. Soc. of Corn.) has tabulated a large no of observations, and he found in the lodes he examined that 22·7 per cent were intersected by cross courses and not heared.

heaved to the right hand 51.1 %
to the left 26.2 %, so that the miners are not
far wrong on going to the r. rather than to the left.
Those heaved to the side of the greater angle were 63.5 %
to the side of the smaller 12.9, and the mean
distance of throw was 16.4 ft. Schmidts' rule
holds good in the majority of cases, but in some cases
it does not.

Deposits of ore which put on in some districts many appearance of lodes but which require to be treated in quite another category. We may meet at the surface of the ground an appearance like that of a lode, which is in fact an irregular ~~deposit~~ repository, being propagated downwards or horizontally like a regular lode - French "amas" - German "stöcke"

May divide them into 4 classes - 1 Those which follow the plane of contact of two different rocks perhaps for a considerable portion of that plane -
2. those embedded in or closely united with Gneiss or non stratified rocks - 3. Those associated with stratified rocks or with rocks more or less metamorphic
4. those occurring in limestones.

They are frequently noticeable at once as different from the lodes in the materials they contain, from a want of regular arrangement in the minerals which are seldom found in this class of deposits their general character being that they contain a large amount of material in a densely aggregated

form, often crystalline, but usually of very small crystals (eg magnetite Sweden) They are remarkably free from mixture with other minerals, except those actually embedded in them (eg garnet)

Irregular deposits at contact. no remarkable examples in this country - in Iron ore in the Harty. Some of the lodes in these districts appear to present much the same character, but may be distinguished usually by being carried out more regularly and to a greater distance. They occur at the junction of certain porphyries and clay slates - met with in Harty near Altenau and Clausthal; & in S.E. part of Hungary. Here a series of repositories extends 30 or 40 miles. occur where a series of secondary rocks are brought into contact with a great band of syenite, which crosses through the country in a N and S direction.

Irregular repositories in non stratified rocks.

Stockwerke of the Germans, in N. Bohemia and Saxony - Some been from an early

period worked for tin. Usual feature is, that is a granitic rock, flanked by gneiss & mica schist, a vast no of small veins occur rendering it advisable to remove large quantities of the rock itself In doing this it is very difficult from the nature of the workings, the nature of the ground, and the oxidation of the rock, to work it with safety. Devres name from fact that workings are in successive levels, or 'stocks' In other districts is gold instead of tin. In Cornwall, near St Austell is a great open working, a 'stockwork', but it is not really such, partly because the strings run in same direction like little veins, and partly because the working of china clay has led to it forming a great open work.

Other repositories are "tin floors" of Cornwall at no great distance from or adjoining the lodes Near St Ives - W. Cornwall - irregular deposits "carbonas" - met with not far from the lodes but pass off from them, the communication

between them being perhaps only a film of Quartz.
They pass off into a kind of pipe which generally
speaking has been filled with material, like
coarse granite but containing tin. Generally a difference
between this material and that of the lode, though
there is a close analogy - Shorl is prominent constituent.
Most remarkable case was at East Wheal Lovell
Sometimes a carbona has entirely between two levels
being limited above and below -
Most remarkable in Europe is Monte Catini Mine in
Tuscany which resulted from the following
down of a tongue of Cu ore, which opened out
into a wonderful mass -

3 Irregular deposits in Stratified rocks.
Example the Great mine of Rammelsberg (Harz)

4. Ores in Limestone a deposit of Lead ore
Fauny mines - Flintshire - neither lode nor bed
but a series of irregular masses.
The "flats" of N. England. Alston moor belong to this class.

In Yorkshire - Swaledale - and the 'pipe' veins of Derbyshire - and the great deposits of Hematite in Whitehaven & Ulverston districts belong to this class. They are great washed out portions of limestone

Deposits of Brown Hematite at the S. border of the Forest of Dean - occur in irregular excavations, in rocks of dolomitic limestone which are termed Churns. Average height 10-20 ft.

10. Operations of a preliminary character which usually precede the opening out of a mine

'Costeaning' is term used by miners, and in colonies 'prospecting'. The first difficulty is resulting from the fact that the rocks is covered by deposits of sand and gravel, vegetable matter and vegetation in in some places by peat-bogs. Hence most mineral have been discovered by accident - by boys fishing at Darkstock - In other cases the pellets picked up and found in the crops of birds, as of Gold in lower Hungary, or again where the ducks in Australia picked up grs of gold. Copper ores of Wallaroo, in S. Australia, discovered by observing some green copper in the material thrown out by the wombat. This discovery of Gold by Col. Sutter, a Saxis emigrant in California, by cutting a water course. (1850)

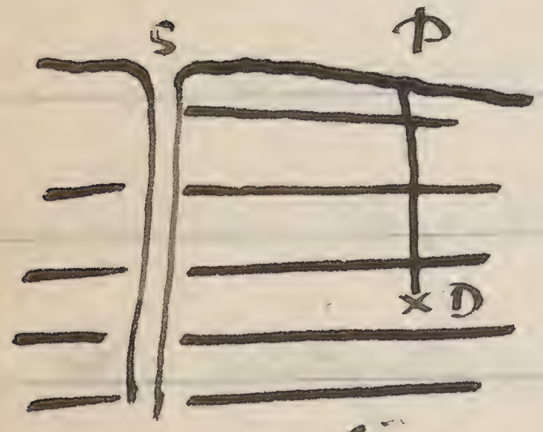
Rammelsberg by the pawing of a horse. - Schemnitz boys chasing a lizard.

The best guide for the search for stratified minerals is a thorough knowledge of Geology. Great mistakes made for want of knowledge

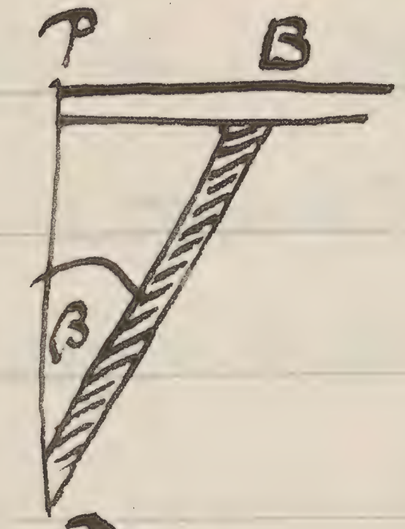
e.g. Coal is supposed to be present because the soil is coaly clay., or because there is limestone near, or sandstone, or because the wells deposit ferruginous matter.
An evolution of fire damp from the ground indicates the presence of coal. these occur largely & sometimes used for artificial light as in fire wells of China, in Hungary for lighting the mine.

In searching for minerals not stratified - we may have three different objects to pursue.
1. to determine the course or the back or outcrop of a lode already known.
2. to discover the branches or parallels or neighbouring lodes in a district already known.
3. to explore new ground.
In 1 & 2 we have a series of elements given and have to find the rest. When a lode has been worked and is enclosed on both sides by the same rock, we shall require to trace

its average direction - (for some hundreds of fathoms) then we may reasonably expect the lode to continue in that direction



It may be that we come at a point D after working only a tolerable lode at some distance from the shaft S, on a rich deposit and we require to find the back of the lode, where from over etc on the surface there is no trace of it - This we can limit more or less by knowing the general strike of the lode, but we can approximate more nearly to it by trigonometry. Let fig. represent a transverse section through D and DB the lode, then knowing the depth of PD and the angle β we can determine the distance PB.



The discovery of the lode will be much easier if it be a contact deposit & if we can determine the junction of the two rocks which form the wall

but lodes rarely have this character - Where the back of the lode is of a hard material, which resists the degrading influence of the atmosphere better than the country round, this back will be marked by a ridge,
Where the back is hidden by superficial deposits we find it by trenching or 'costeaning'.
If the superficial deposit is not more than 5 or 6 ft a line is taken at rt. angles to the general run of the lode and a trench is dug to lay bare the rock - lodes are often changed at the surface; what has been a good lode below may be at the surface only a few strings of stone.
If surface accumulation is from 10 - 20 ft. then 'costeaning' is employed, in principle the same as the last - but instead of going to the expense of digging a trench along the line at right angles to the lode, a shaft is sunk on each side; & then a cross gallery is driven between the shafts - and the sides of the cross cut examined for indications of the lode.

Examining for series of parallels or branches, or side lodes is done in the same way, this is a point too often neglected.

Reopening of old mines. When possible obtain official documents, but often difficult to get these. Remarkable instance of reopening was. Wheal Vor Mine in 1855. It was known by documents to be very rich and had been worked to 300 fathoms, abandoned 20 yrs - after £25000 had been spent in clearing it of water - it was found not to be worth working a mine

XI. Principles by which the miner must be guided when exploring ground of a new character, or in a new district_ both as to the lodes and other repositories Rules laid down by Agricola, the old writers thought that the mere latitude of a district would be a clue to the minerals to be found there, eg. gold & gems in the tropics, coal in more northern latitudes — Presence of coal in Borneo, China and India, & gold in extra tropical latitudes shows that this is not correct .. Again it is stated that in a mountainous district there is not so much probability of finding mineral deposits in the rugged precipitous central chains ~~as~~ but rather in the subordinate parallel chains which usually are of a more gentle and rounded character — (borne out by position of the mining districts of the Alps & Himalayas.

Another point to be regarded if we follow these older writers, was somewhat fanciful, that we should seek for the lodes on those hill sides whose

face the sun or a stream of water.
A ridge in the ground may sometimes mark the back of a lode - (eg Vulture lode - Vickenburg - S. America 80ft above ground)
or a ~~de~~pression - (eg in the Yorkshire moors)
The old miners thought that snow would not lie on the backs of the lodes in the same way as on the country round.
The position of some classes of lodes may be found out by a tolerably acute sense of smell, the presence of pyrites etc giving rise to SO_2.
Next we come to a phenomena which it may be said is apocryphal - it is - that on the backs of certain lodes, in particular conditions of weather a series of corruscations of light may be seen playing, like a lambent flame, and it is said to have led to the discovery of lodes. When we think of St Elmo's lights playing about the masts of ships, we can not but think there is something in it.
(Must not be confounded with gases burning for a length of time which have led to the discovery of coal fields)

The belief in the divining rod.

Dr Pryce, Mr Cookworthy were believers and adepts in its use. M. Chevrant wrote a treatise on the subject

Examining in a new country for mineral lodes.

Take the banks of a river and examine the rocks for an appearance of the lode, then examine the bed of the river. Note the pebbles. If they are large and angular they have not traveled far., if rounded and smooth they have been carried a great distance. Knowing the direction of the lodes, we dig our trenches, or costeaning pits and try to come to the lode.

In some parts of N of England — Moorland district — the miners have a method called "hushing" of saving themselves the trouble and expense of costeaning or trenching. The method consists in selecting a little hollow at some distance from the stream, and damming it up so as to collect the rain or spring water and form a kind of pond. When sufficient water is collected it is allowed to

rush suddenly down towards the stream, tearing up the soil as it goes. This is repeated until the rock beneath is laid bare, when search can be made for the lode.

12. In examining a lode as testing as to its value we must test it at a great number of points. The correct course is to take fair and average samples

of the lode from a great number of separate points, either from the surface or better still from underground and then mix them all together, build them up in a circular pile, cut it through by cross trenches then mix the material taken out with others taken from the middle of each quadrant, then make this into another pile and proceed as before.

Where we have to make an examination of a lode we must test it at several points and this we can do in a hilly country in two ways, either by sinking shafts or by driving levels.

The choice will depend on the dip of the hill and the underlie of the lode. The great advantage of a level is that it drains the ground above it

and may remain is use, should the lode prove worth working. If things look well it may be worth while to drive other and longer levels lower down the hill, & if the ore ground extends downwards, to drive an adit level as far down towards the bottom of the hill as possible, in order to drain the whole hill above.

But if it be an unfavourable rock in that part, it will be well to be satisfied with shallower levels, until the works have been opened, and sufficient capital is secured to enter on a larger level below. If the lode dips with the hill, it may be most profitable to drive levels, but if it dips against it then it would be best to sink a series of shafts.

A few considerations as regards the preliminary operations in connection with mining, which require to be attended to.

1. the consideration of what sort of partnership you are to work under, from whom you are to take the minerals and under what conditions

2. The power you can have for your machinery, if water, whether you can always expect it on the spot, or whether it will be necessary to collect it in reservoirs, or convey it for a distance may be of 8 or 10 miles as in some districts of Saxony. The question of altitude above the sea is also important.

3. The means of carriage to or from the mine, whether there are good roads, or whether (as in N.) it is necessary to use 'galloways' or ponies, or other animals for carriage over bogs etc.
Also question of railways, canals, and sea communication

4. Whether wood or timber is at hand, or whether other fuel can be obtained, whence Coal? and its price

5. The consideration of the wages, skill and industry of the miners and proximity of their dwellings to the mines, for if a workman comes a long distance you can not expect so much work for him as if he lived close at hand. This is so important, that sometimes it may be advisable to erect temporary barracks, but the extra expense is a drawback.

bad management, (a definite plan of working necessary,

6. The consideration of some matters connected with the surface. Caution against overbuilding at the outset, but do not pinch the men. Some stores must be at hand.

In the very largest class of works it is necessary to have stables, granaries, foundries, and workshops on a large scale.

XIII. Boring (French "sondage")

Earth boring or deep boring — consists in putting down holes from 1½ to 8 or 10 in. in diameter ~~from~~ to a depth of 10 – 3000 feet or even deeper. The objects for so doing are 1. for testing the character of the ground at moderate depths, as for the foundations of buildings 2. for exploratory and precautional operations in mining, particularly in mining stratified rocks. Proving the existence, position, thickness, or quality of the various strata through which it is proposed to sink or to relieve principal workings of the water, or to secure proper ventilation 3 for affording an outlet to subterranean waters — ex brine springs & artesian wells. 4. For the sinking of shafts, especially successful where there is much water, and where, sinking in the ordinary way, the expense of pumping would be overwhelming.

In sinking bore holes of the first class, very simple apparatus may be used — wimpels and scoops of various forms, according to the kind of rock.

A very general form is that of a cylinder, with a cutting edge round the bottom and a slit up one side, looking like a gimlet. They are worked by a handle on the tool or by a bar of wood passed through an eye in the head of the tool.
The expense of putting down deep holes is very great, to 1000 feet, will cost £1000 to £3000.
In stratified deposits a single bore hole will give much information - but if there are irregularities one is not enough.
There are other instances where the mine has been tested by horizontal boreholes, where, for instance, such boreholes are kept in advance of the actual workings when in the neighbourhood of old workings, which may be full of water.
In all such cases, and whenever old workings are approached so near as to be associated with risk, it is desirable that the horizontal boreholes should be driven in advance, not one only, but three one in the direct axis of the workings, the other

one on each side, one in the direct axis of the working, the others one on each side, at an angle of 45°. to discover any side workings there might have been. The men must be supplied with long taper plugs, which at the moment of the water making its appearance must be driven in. These advance bore holes should be 4-6 yds in advance

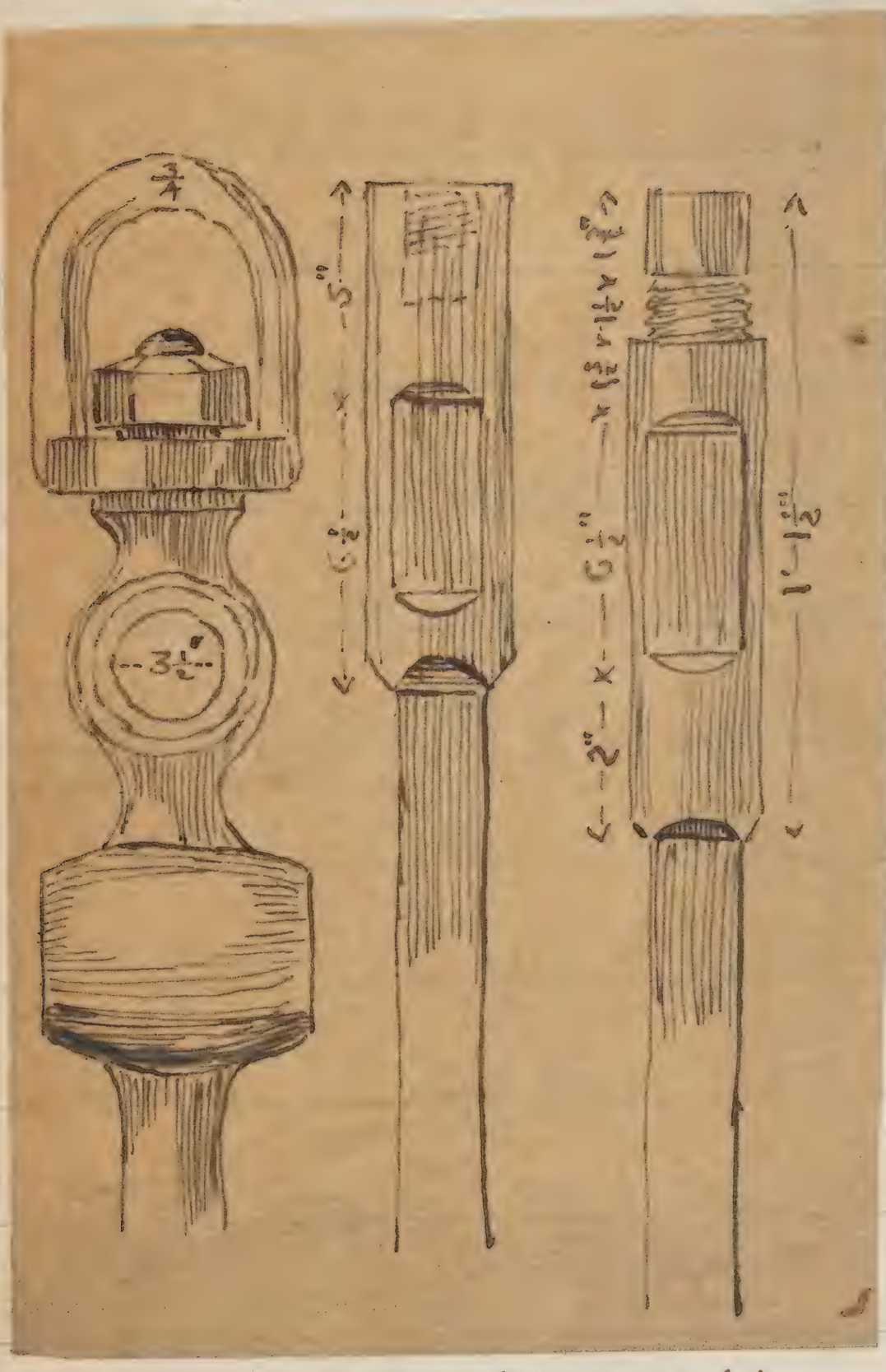
The borer consists of some heavy instrument of the scoop kind for soft ground, of the chisel kind for hard ground. It is suspended by rods of iron or wood to a swivel hook at the extremity of the apparatus by which the whole is worked. The form of the cutting tool varies according to the nature of the ground through which it has to pass. Some borers prefer to have two cutting edges, at right angles to each other, others a cutting edge combined with a portion of the circumference of a circle and so on. The rod and borer are raised a few inches and then allowed to fall, the

cutting edge being made to fall every time in a fresh place by the borer master turning round the rods by means of an apparatus which clutches them near the upper end. When enough rock is broken, the debris is removed by lifting out the borer and putting down a tube, a "sludger" from 4 to 6 ft long with a valve at the bottom. This may be let down by the same series of rods, which is the most prudent, or by a rope which is the most rapid, in the latter case the rope may happen to break and the sludger be left in the hole, causing great difficulty and delay. When such occurs one must endeavour to lay hold of it by a nipper like arrangement - or if all such means fail to chop it to pieces with the hardest steel instruments and then remove the pieces by a fresh sludger.

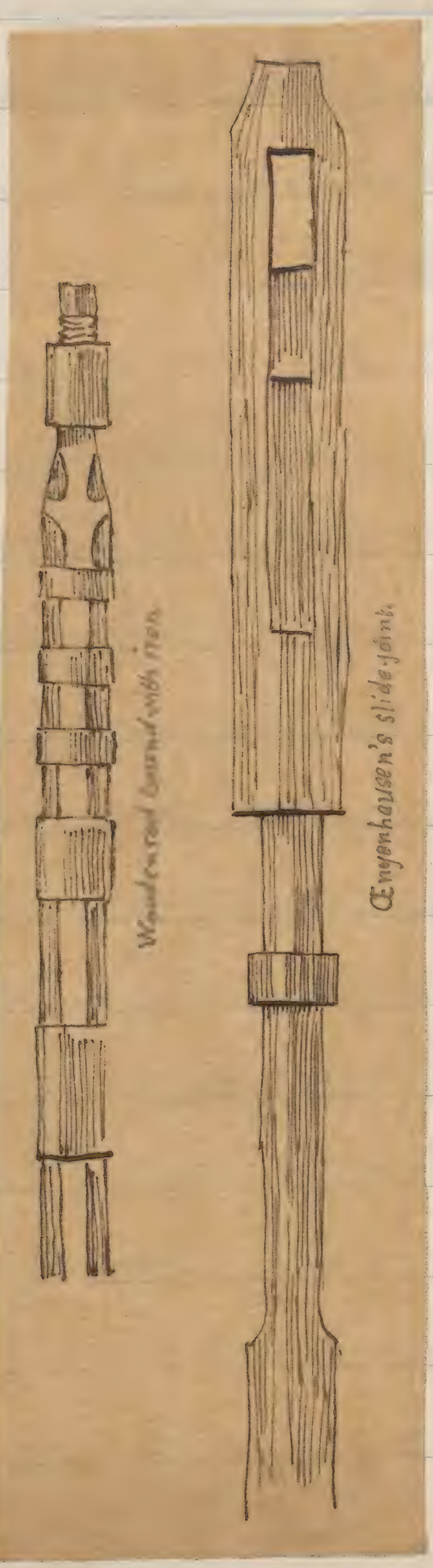
Sometimes the rods are joined together by a screw blade joint, but the best mode is by screwing. A small shaft is usually drilled round the borehole

in which a man or two can be placed.
When the rods are being withdrawn, they are raised up and the swelling just below a joint is caught on a fork until another joint is screwed off.
One of the greatest difficulties is where the rods break in the hole and fall in an awkward position.
For bore holes of ordinary character the rods are about 1 inch square - joined in lengths of 6, 9, 12 or 18 feet and weigh about 22 lbs a fathom.
One of the most frequent modes of raising the rods in moderately deep borings is by means of a windlass, with a slack rope. The great drawback is the wear and tear of the rope, so a chain is sometimes substituted.
Another plan is to use a lever, the rods being attached to the short arm and the men working the longer arm. In our coal districts another plan is often employed - A spring pole has one end fixed into the ground, a fulcrum is placed

near to that, and the rods are suspended from the free end. The blow is struck by depressing the end of the beam and the rods are raised again by the elasticity of the beam.



(Head and joints of iron rod.)



XIV. Very deep boring.

Most remarkable in this country is the bore hole at Battle, in Sussex, sunk for scientific purposes, to a depth of 1800+feet.

The bore hole for the well of Grenelle in France 1800.

At St Louis, and Louisville, in America, and the one at Mondorff (Westphalia) ove 2200 feet.

That of Creusot in France - 3000 feet - put-down to find coal - Since that a deeper borehole has been sunk at Sperenberg, nea Berlin, has a diamete of 14-15" inches - and was carried to a depth of 4051 feet.

The number of difficulties increase with the depth, the accumulating weight of the rods - and the vibrations set-up by the concussion, which loosen the joints and tend to destroy the fibres of even the best iron, and the striking of the rods against the sides. Methods to obviate these difficulties have been proposed by Paton, Kind, Degoussée and Laurent. When the borings reach such a depth there are several means of raising the apparatus - e.g.

the rods may be suspended from the short arm of a lever in the form of a great beam, the longer arm of which is connected by a chain or rod of iron with a point near the middle of the 2nd beam - one end of the latter is fixed, and the other is depressed at intervals by large teeth set on a windlass, turned by hand or steam engine.

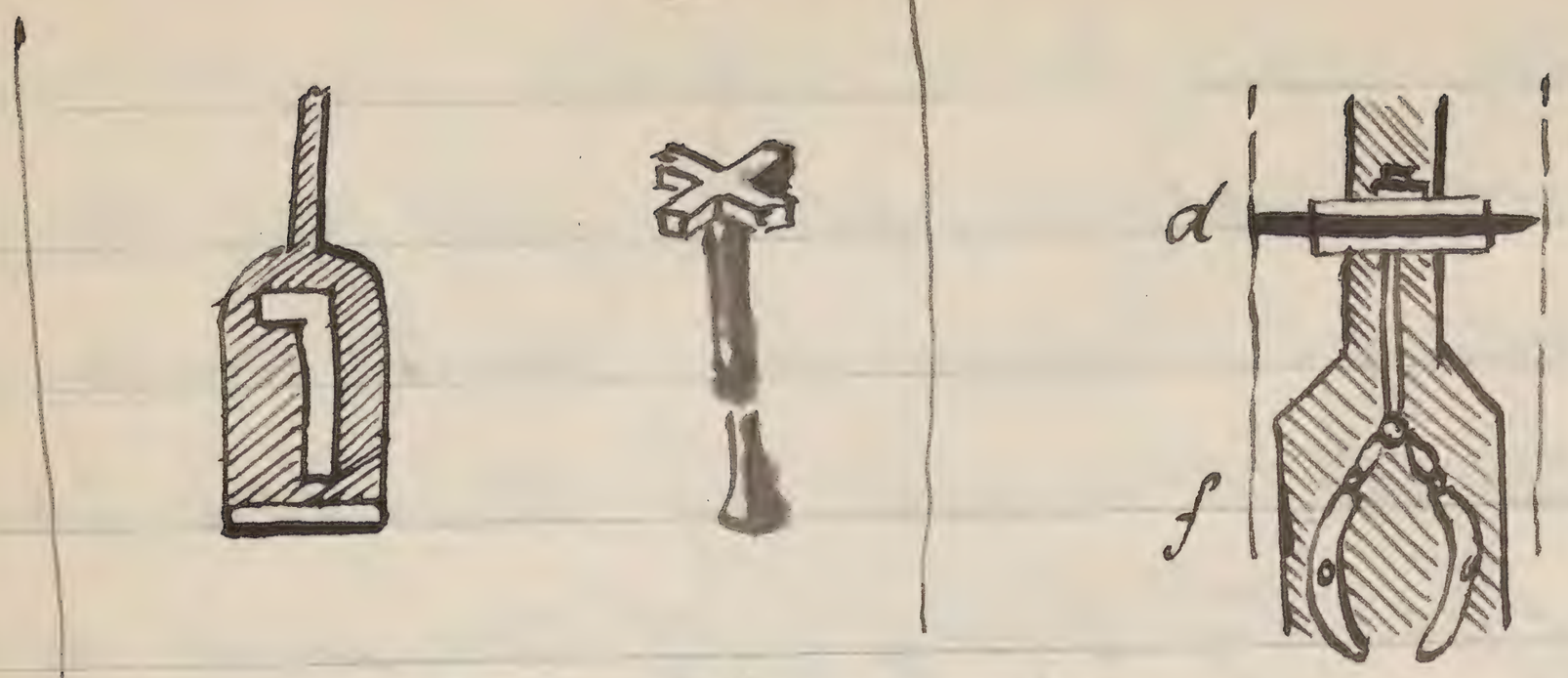
A large framework of shears, frequently one of the ordinary triangular form is erected and other windlass used for withdrawing the rods.

To lighten the weight of the rods, it was suggested by Von Oeynhausen to use hollow rods.

Another plan is to use wooden instead of iron rods, these were floated up more or less by the water in the deep bore holes. The rods were from 30-36 feet long, tapered towards each extremity a piece of wrought iron was fixed to each end, by means of plates or bolts, in order to carry the screw by which the rods were screwed together.

The next suggestion was to reverse the boring tool

of the inefficiency due to the friction and vibration of the rods attached above, letting fall only the boring tool, and so much other apparatus as to render it heavy enough to do its work. If then you have a boring tool sufficiently heavy, of course it will be desirable to raise it with an apparatus of the least possible weight. Kind proposed that a very light upper rod should be employed for the purpose of raising the 30-40 feet of heavy rod attached to the cutting tool - but this cannot be carried out beyond a certain point - Fabry (in the Prussian engineer) proposed a falling piece which could be worked by being actually dropped from the remainder of the rods at a certain point and could again be lifted by something in the shape of nippers "Free falling cutter." One form is like this, at the end of the main rod is a cylinder of much larger diameter, in the sides of which are four vertical slots, each with a small prolongation sideways at the top.



(shows the principle but not the proportions

fig. d = the disc
f = the fixed point of lever.

The top of the tool is formed as a cross piece, the arms of which move freely in the slots, and will also lodge in the side prolongation of the slot. It is lifted up in the latter position to a height less than that of the slot and then a small jerk of the rods by the master lever dislodges the tool and it falls. It is lifted up again by lowering the cylinder so that on turning it round it would catch the cross pieces in the side slot

Another method consists in having a pair of bent levers, hanging somewhat like pincers which grasp the tool and raise it - Moveable on the upper part of the apparatus is a disc of leather, fitting closely round the borehole, so that when the

instrument is being raised through the water, the effect is a pressure on the upper surface of the disc, which tends to depress it relatively to the rest. By means of a collar a set of levers act upon the juices so as to open them and release the tool. (N.B. water is rarely absent in deep bore holes)

Dégoussée, dispensed with the disc — thus a heavy rod of iron, hanging down by the side of the cutter and attached to a collar above which would serve the same purpose as the disc in the water.

The next consideration is to obtain satisfactory samples of the material cut through.
The old plan was to chip the whole up into pieces or even slime — Now a cylindrical tool is put down which cuts away the rock round the circumference leaving a central core. Then a 2nd tool is employed, in which by means of a string

a tooth is detached, which cuts away a great part of the foundation of this core - This is withdrawn and a 3rd tool introduced, with a clamp worked by a spring or by gravity so as to catch hold of the core, ~~so as to weaken it~~. which is then drawn away in a lump - Piece, 1 foot in length, may be conveniently obtained, & are very important. You may see the kind of rock you are working in you may bring up some of the rock containing fossils (as at Bath(e)). and you may frequently get a clue to the stratification of the rock

Leschot's method of boring, consists of an annular tube, originally of soft iron, now of steel, in the lower edge of which is placed a series of diamonds – A rapid rotatory motion is given to it, and it cuts its way down around a central core which is withdrawn from time to time in lengths of from 6 – 18 inches. The powder formed by the action of the borer is continuously washed out by a stream of water forced down the hole by a small injection pump.

Modification in the method of suspending the tool practised in China from an early period. The tool is suspended by a rope – wire ropes have been employed. One of the greatest works of this kind was the well at the Military School Paris, 1000 feet deep.

System of cutting of Matter and Platt.
Their apparatus differs from others in the way
of working the machine at the surface and
in the character of the tool below. A flat
hempen or wire rope is employed to suspend
the tool and this passes over a pulley above the
hole and on to a drum being clamped at
an intermediate point during the working.
A small cylinder and vertical piston were placed
so that when the steam was admitted below the
piston, the piston rod might raise the pulley
with which it was connected and with it the
tool, which was allowed to fall by the descent
of the piston — The length of the stroke was
regulated So that the borehole could be worked
up to 12 or 14 in. diam. The tool is a great,
long, and heavily weighed iron rod, lengthened
so as to keep the hole as near the vertical as
possible. Inasmuch as you cannot have with
a flat rope the torsion necessary to revolve the

tool, an ingenious means was adopted for this.
The rope was attached below to an iron rod
which was again connected with a moveable
collar, the two ends of which were cut into
somewhat inclined teeth, the collar could move
up and down through a space of a couple of
inches or so and locked at each end of
its movement with a corresponding set of teeth
on the bar of the tool. These two sets however
were so placed that one was half a tooth in
advance of the other, and the effect of the
alternate locking of the collar with one and
the other of these sets will cause the tool to
rotate through half a tooth each time.

Frequently in putting down bore holes you cannot get a hole to stand for more than a few yds without portions of the walls falling in, hence linings must be provided.
Wooden pipes were formerly used, and no material is so good except that so large a bulk of it is required as to reduce the bore hole almost to nothing. Materials used are cast and wrought iron, copper, bronze and Zinc according to the nature and corrosive effect of the water present. Wrought iron is generally favoured-, Zn. is employed with advantage with Sulphurous waters.

The tariff at Newcastle some years ago - was 7/6 per fathom for the first 5 — 15/- for the second five and so on.

XVI. Breaking the ground, the perforation of the rock.

We may divide the different kinds of ground into 5 classes. 1. soft, loose, or running ground. (Ger. lockeres rollig.) — this is soft watery ground, occurs even in Cornish granite districts called "plumb ground"

2. fair ground. easily cut by tools wielded by hand

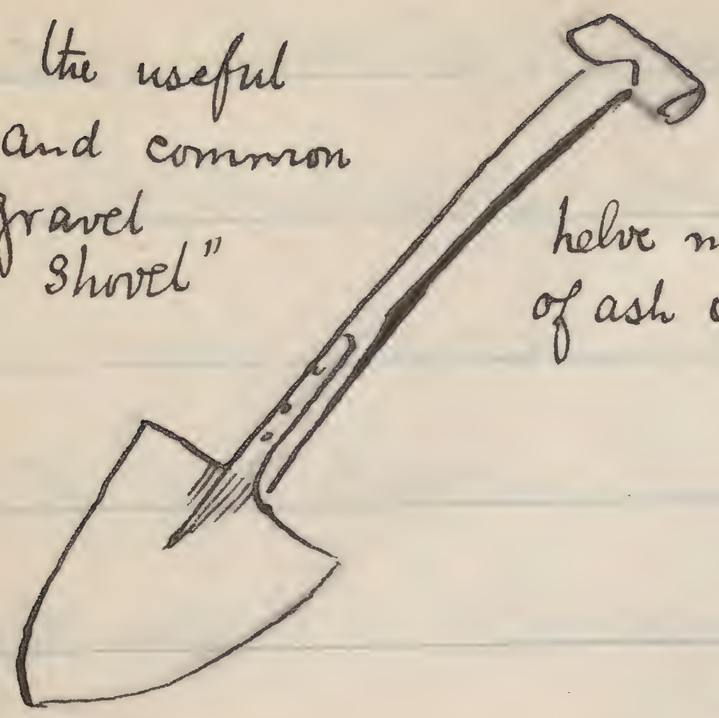
3. Jointy or scaly ground. "klug" "kleiftig" needing good tools — 2 and 3 may be called pick ground

4. Strong or shutting (shorting) ground. "fest" — needing explosives.

5. Höchstfest, tight or close ground requiring special means of working it.

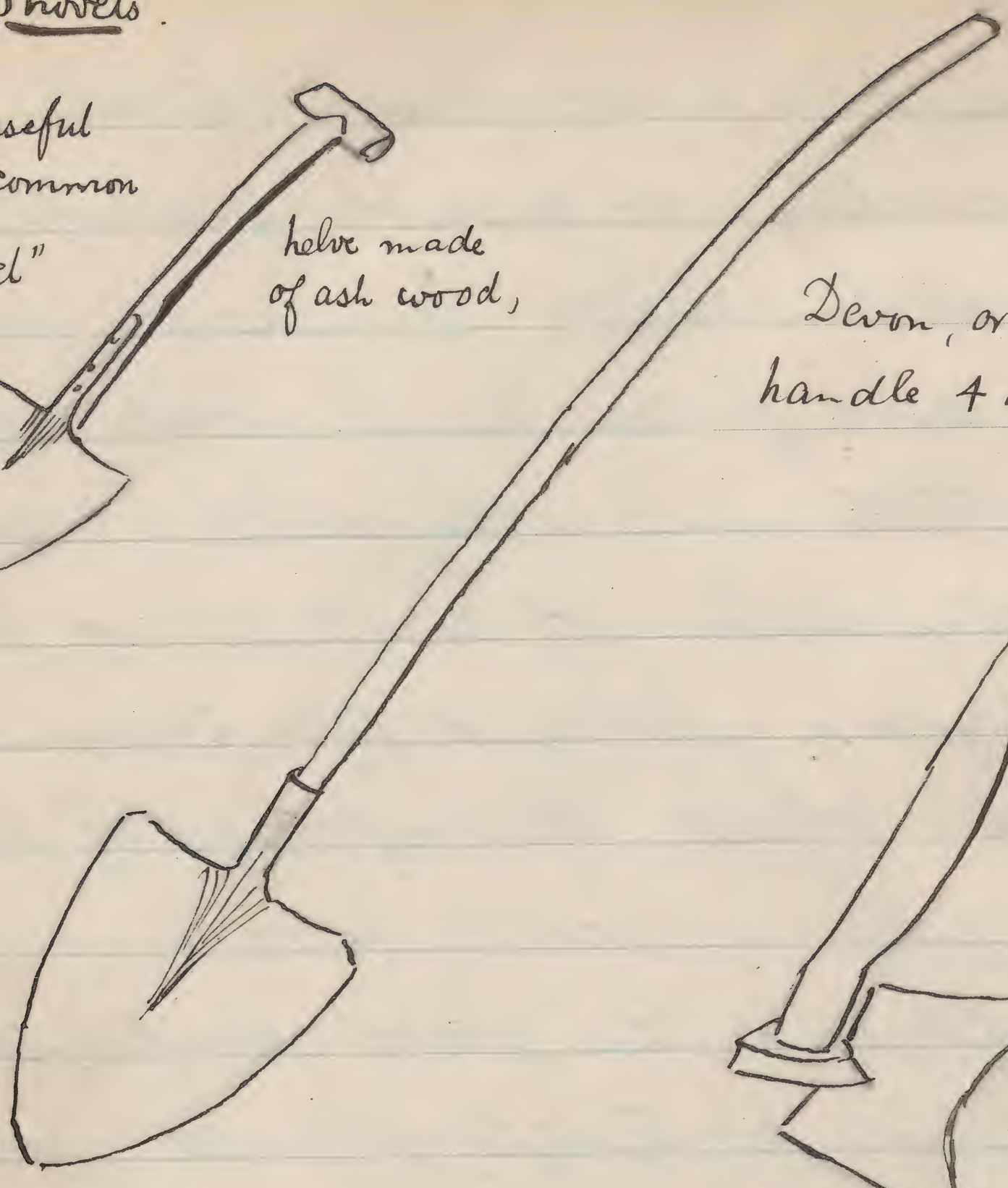
The implements used - 1st class - to remove the material as quickly as possible, and provide for the safety of the men.
English shovels are for overhand work but on the continent tools are very often for underhand work. Another class of shovel must be mentioned which is employed in gold and tin stream works that has for its object the sifting of the material to a certain extent.
For the 2nd Class - the pick is employed, in W. of England a single pointed pick is used. The Cornish pick has a hilt somewhat curved forward towards the point of the pick, made of the best wood, as ash, the head is of best iron, 15 in. long. The ends are steeled one as a point for picking, the other as a hammer - the pick is also used as a lever, the leverage being obtained by means of the long handle, and the part about the eye has to be strong enough to bear this.

Shovels.

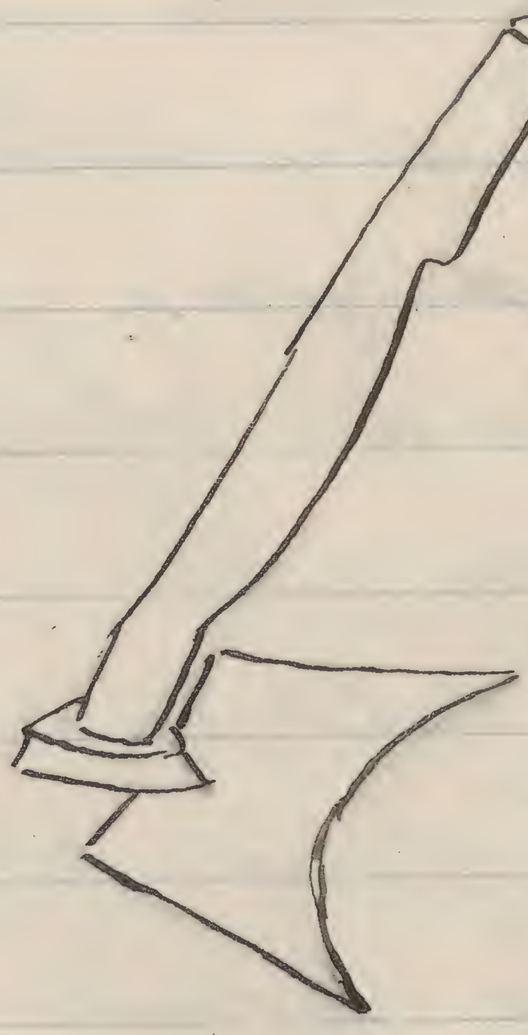


the useful and common "gravel shovel"

helve made of ash wood,



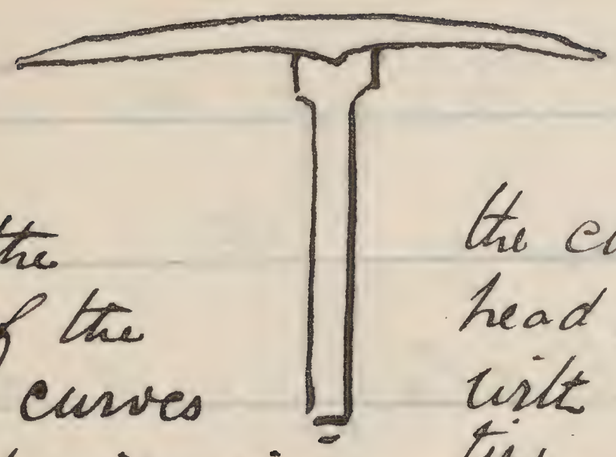
Devon, or 'long handled shovel. handle 4 or 5 feet long



Saxon shovel - more like what would be called a scraper in England

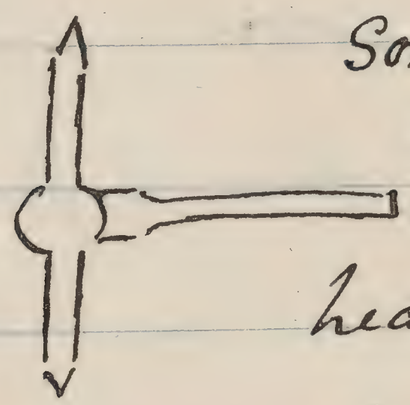
Picks.

('mandrel,' "pike", "slitter," "mattock", or "hack")



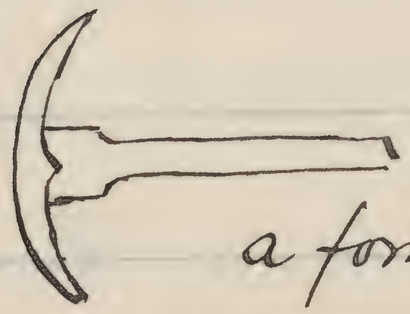
When the head of the pick curves slightly it is said to sweep.

the common pick head of wrought iron with steel at the tips -



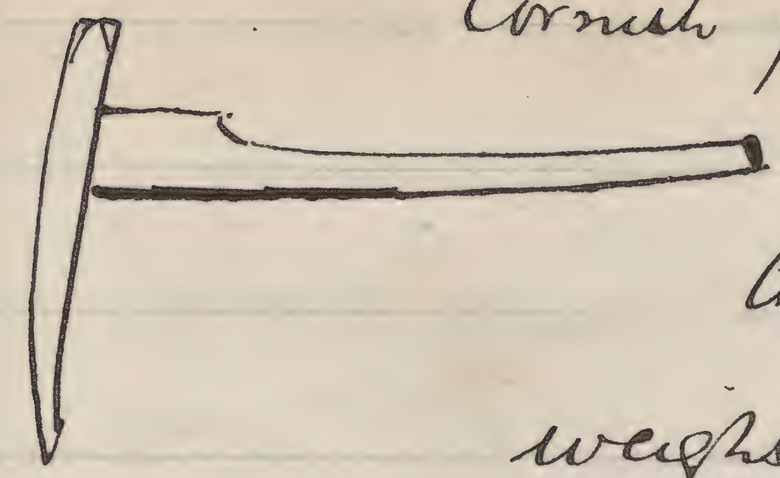
Sometimes there is no curvature then the head is "straight"

Pick heads vary in weight from 2 to 8 lbs.

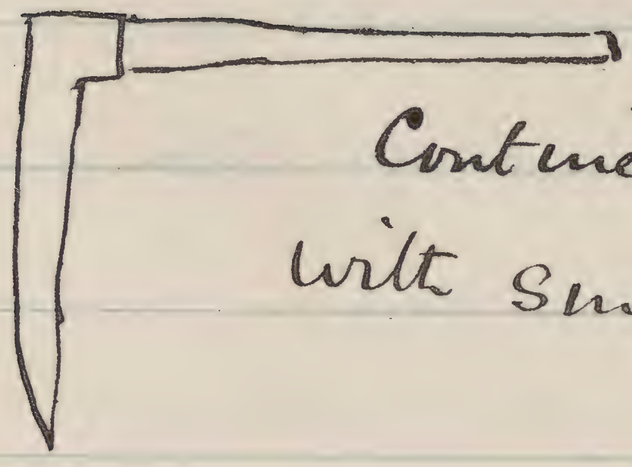


a form of pick much used in iron mines.

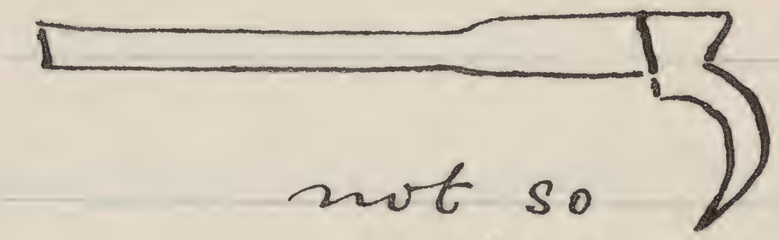
The helves are generally 24 - 33 in. long.



Cornish "poll-pick" one stem about 12 in. long, and one stump about 3 in. the eye is 2½ in. long. the head weighs 4 lbs. helve 26-28 in. long.

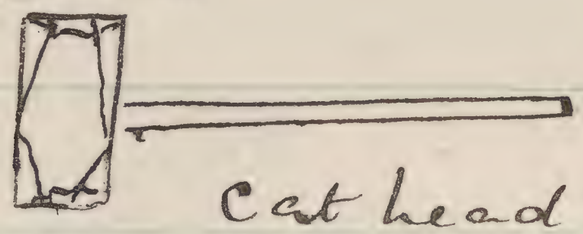


Continental pick with single stem.

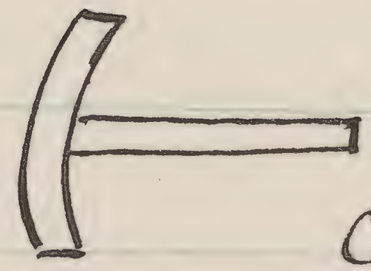


not so well balanced.

Hammers.

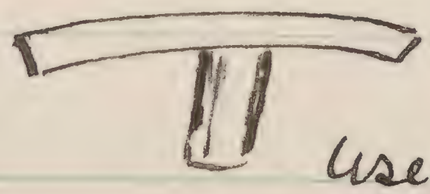


Cat head Cornwall

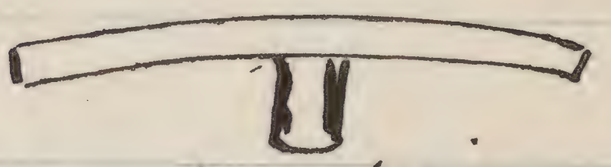


Cornish

Saxon

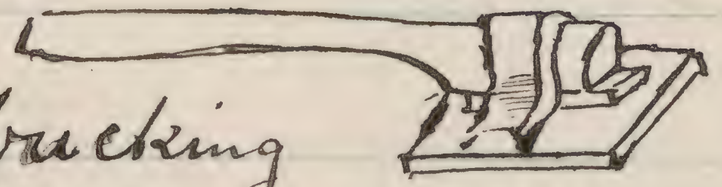


used in Siberia

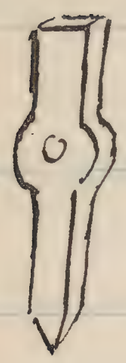


used in Mexico

cobbing hammer used for dressing ores by hand.



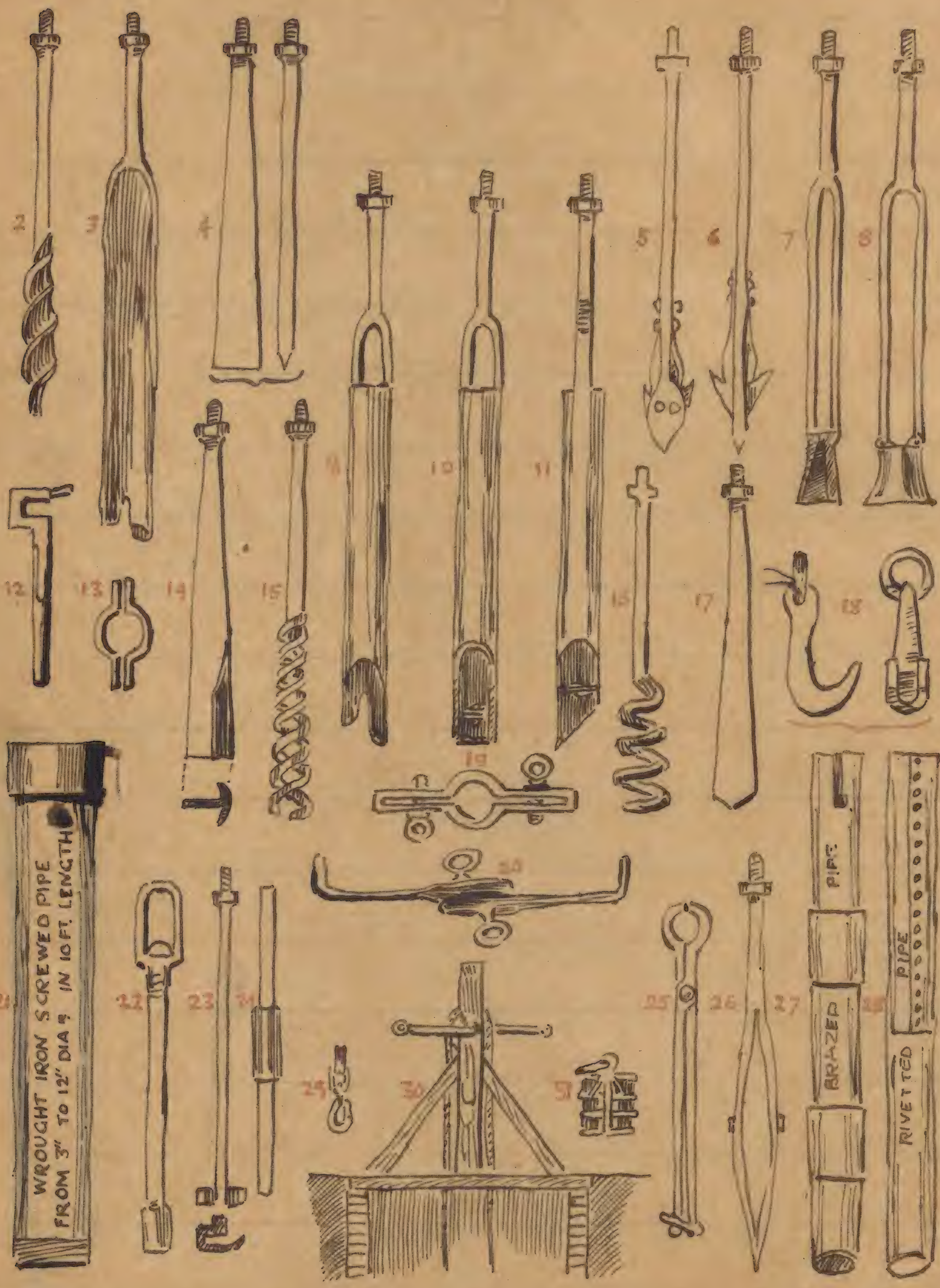
'bucking iron' - used for hand crushing in dressing ores.



Saxon gad. / having near the middle an eye which is used by Saxon miners for threading several on a sling. Leaving the man's hands free for climbing

Plug and feathers.

The hammer and wedge were in former days, the chief means of breaking ground of considerable hardness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21
WROUGHT IRON SCREWED PIPE
FROM 3" TO 12" DIA. IN 10 FT. LENGTHS
22
23
24
25
26
27
28
PIPE
BRAZED
PIPE
RIVETTED
29
30
31

Boring tools.

1. Well rod - usual length 10 ft. 2. worm auger
3. Open auger for clay 4. flat chisel for stone or flint.
5. Spring dart to draw faulty pipes from bore hole.
6 " " for smaller pipes
7. Bell screw for with drawing broken rods.
8. Bell box for " "
9. Auger nose shell - for similar purposes with valve for loose soil or sand
10. Flat nose shell. 11. Shoe nose shell for harder ground.
12. hand dog for screwing & unscrewing the rods
13. pipe clams or rests. 14 T chisel for flint or stone.
15. wad hook - for with drawing stones etc which may fall in.
16. Spiral angular worm for with drawing broken rods.
17. Diamond or drill pointed chisel for hard ground.
18. Lifting dog, for raising and lowering the rods
19. Long pipe clams or rests.
20. Tillers or levers for turning the rods
21. Wrought iron Screwed well bore pipe.
22. Short rod with swivel head
23. Crows foot for extracting the broken rods from bore hole.
24. Pair of well rod joints ready to shut up for greater lengths.
25. Pipe tongs or heaters for making joints in pipes.
26. T-piece or Pipe dog for lowering the pipes.
27. Brazed and Collared pipe, with water tight soldered joints
28. Common rivetted pipe, Strong make.
29. Spring Hook to be attached to well Rope for raising tools.
30. Windlass complete for boring or sinking
31. Strong well sinking bucket.

Bennett Hooper Brough.

Lectures on

Mining.

Prof. Warington Smyth.

Royal School of Mines

* *

Lecture XVII.

The wedge is used to obtain stone blocks without the use of gunpowder, which would shatter and injure the structure.

Another plan is that of boring holes into the rock in proper position and then inserting wedges of dry wood, these are moistened or left to the action of dews.

Within the last few years much attention has been given to the question whether it is not possible to do without gunpowder in the getting of coals — Mr Bidder proposed to bore at intervals along the face of the coal a set of holes by means of a power auger, the hole being about 2 feet long and 3-4 inches diameter and bored in about 25 minutes. Into these holes were to be inserted a series of iron cheeks and then a number of long wedges were to be forced in between the cheeks by means of a small Bramah press, which was constructed so as to be easily carried about by two men.

Mr Jones' method was to introduce a cylinder into the aperture at the top of the coal, from which cylinder a number of little pistons projected above and below. By means of the pressure of water, from an ordinary Bramah press, the pistons were made to project more and more, until at last the pressure was sufficient to force down the mass.

The introduction of gunpowder for blasting is but of recent date _ late in the 17th century.
Among the tools used for bore holes we have 1. a long iron bar, with a cutter at each end _ bar is 5-6 feet long with a swelling towards the middle. It is called a "jumper" 'borer' or 'auger'
One end cutter is commonly wider than the other so that you can commence a hole with the wider one and then continue with the smaller.
The fragments of broken rock are removed by a 'scraper'

In most mining operations in nearly all districts the common instrument is a boring ~~drill~~ bar - in S.W. called a 'borer', in other parts a drill, mandy, auger or jumper, in Germany a 'Bohrer', in France a 'fleuret' or 'pistolet'. It consists of a bar of iron or steel, with a cutter at one end, the other intended for receiving blows from a hammer.

The bars were formerly of the best bar iron, tipped with double shear steel, but now they are made entirely of cast steel.

XVIII. The hammers used are single or double handed. The head is of iron, with a face of steel Double handed boring is preferable a. the whole to single handed boring.

The character of the materials the miner may best use for explosives.
The majority use blasting powder - Substitutes are White powder - in which soda nitre is used : etc
Nitro glycerine, now forbidden - Dynamite and guncotton now compete with gunpowder.
Guncotton used to be rolled up into cylinders but has now given place to Abel's compressed guncotton

If we blast with powder, and have the hole ready bored, the powder is introduced and pushed down to the bottom by means of a cylindrical piece of wood, the sides of the hole being cleaned as much as possible from adhering ~~pieces~~ of gunpowder
One must see that the men do not use an iron or steel tamping rod for this
The tamping material used varies considerably, dry sand is very successful - in the mines it is better to use dry clay, powdered brick, or killas —

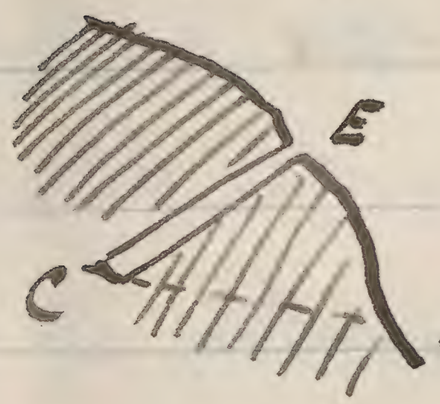
In some cases this is of iron and steel, and there is then a great liability to accidents, except in very soft ground, in other cases a bar of wood, copper or brass is used, or the charge is fired by a safety fuse. When the needle was withdrawn the hole was filled with a train of powder and at the top a match, (string dipped in Sulphur) was placed so that when it was lighted, it would give the man time to escape. Another method of firing used formerly was by means of goose quills filled with fine powder

XIX. (Read Sir John Burgoyne's work)

With respect to the firing of charges, when it becomes a matter of import-ance to fire a number of holes at once, we must introduce the method of firing by the electric machine, or galvanic battery. This has been used since the blowing up of the Royal George by Sir C. Paisley.

It was long ago found that as you increase the distance from the charge to the exterior at which the charge has to be released you must increase the amount of charge.

It is found that as the distance increases the amount of charge must be increased in the proportion of the cubes of the distance.



If CE be a bore hole & CD the direction the charge is likely to take effect, CD will be called the line of least resistance. If the line CD were longer than CE and if the resistance of CE were not helped in some way

or made greater than that of CD, then the line of least resistance might come to lie in CE, and the only effect of the explosion would be to blow out the tamping. According to the rule if we had two borings under similar circumstances except that in one the line of least resistance measured 6 ft, and in the other 7 feet, if 22 lbs of powder were required for the former, the quantity (35 lbs) required for the latter would be calculated $6^3 : 22 :: 7^3 : x$

A square box of 1 foot side holds 57.6 lbs of powder — One 3 ft 4 in. side holds a ton.

In a blasting at Holyhead, where two chambers were fired simultaneously, the one nearest the exterior contained 1800 lbs of powder, the other in which the line of least resistance was 33 ft — contained 2400 lbs — The quantity blown down was 10,000 tons! being at the rate of 2½ tons for every lb of powder.

Another method of working a way through the rock is the method of "fire-setting"
At Felsobanya a simple machine (Pregelkalge) is employed on which to lay the burning wood It is a small iron frame, supported on four legs (like cats' paws, hence the name) the top of the frame is inclined downwards towards the face to be worked, it is 2 feet 6 in. long slightly wider from front to back, and arched at the top It can be set on the ground or on a platform of stones etc. according to the height to be worked. Having been placed in the level, the wood is carefully stacked on, and a plate of iron laid on the top, the wood is lighted and the draught being duly managed, the flame will impinge on the face of the rock, the smoke and the products of combustion passing along the top of the level. The men creep along the floor, and supply fresh wood as required by means of a long forked implement, like a boat hook

They arrange the fire so as to place in the best manner. After this has gone on for some time loud cracks are heard, the moisture present in the rock being converted into steam.

XXI. Paying the men.

There is a general resemblance between the positions held by men in coal and in metalliferous mines In collieries the prominent In metallic mines manager is the "viewer"; often this is paralleled by there is a 'consulting viewer'. the manager or superintendent Under or resident viewer under captains over men a grass captain with deputy overmen. duties at the surface Road men Pitmen and shaftmen masons woodmen and timbermen waste men and masons. firemen.

Then among the body of the workmen are

Hewers
Putters
Rolley drivers
Trappers (boys to see to the ventilating doors)
Onsetters or Hangers on (at the bottom of the shaft)
Banksmen. (at the surface to receive the material)
Besides these are labourers, smiths and in great works fitters etc.

{ tributers / tut workers

Trammers
Fillers
Landers.

(see end of this volume)

XXII. Method of working in metal mines, here the rock is generally much harder than in coal mines - A full complement of men will perhaps not advance more than 1/fm. per week. The ground is so hard that a plan of the mine must be settled long beforehand

Representing mines on maps and plans is very simple respecting collieries, the workings there being deferred to a horizontal plane. The part representing the coal withdrawn is, in some cases, coloured dark, in others the pillars left have the darker tint, faults are marked in with a yellow line, and the course of ventilation marked by arrows. Plans must be prepared on a scale of 2 chains to an inch. It is usually the case in British metal mines to represent the lodes or levels by single coloured lines in plan, the lines being drawn straight between points in the lode, determined by the theodolite or compass. It conduces much to clearness to indicate the levels by means of double

lines filled up with colour. A better plan is that adopted at some of the Hungarian mines, where the double lines indicate the actual walls of the level, and where certain signs indicate the actual walls of the level means of securing the level in those parts and other details

The plans are often accompanied by a vertical section of the workings. The scale of the drawing, not being fixed by Parliament, varies much 8 or 10 fms to the inch often used or if large scale 5 fm to inch is adopted

XXII. Working in open works or quarries.

The vegetable soil is pared off and placed in a suitable position to be spread over again, when the works are concluded, the waste is shot back and goes towards filling up the excavation

Report on Devon and Cornwall by Sir H. de la Beche.

Stream works for gold in California

(see J. A. Phillips' book)

Hydraulic mining proved an enormous success. Water courses were cut to bring the water from the high grounds to the parts where its power would be required. The water is then brough down from the flumes by a sheet-iron pipe into a cast iron box, placed on the floor of the working, thus obtaining a pressure of 60-140 ft. There are a series of valves in the box which can be opened so as to admit the water into flexible pipes, generally of canvas, strengthened at intervals of 2"-3" by iron hoops or by a net work of cord. The pipes end in a nozzle like that of a fire engine, diam 2" to 3", and a jet

of water can thus be brought to play on the face of the gravel through which the gold is disseminated.

Illuminating the workings.

In some Scandinavian mines torches and large open lamps are used. In some continental mines where there is nothing to interfere with the steady working, large candles of 6 or 8 to the lb are used, generally 18–24, in colliery districts, where fire damp occurs, thin candles of 30 to the lb were formerly used. The candle and the miners hand were formerly used for testing for the presence of fire damp. Among the methods of holding the candles we may notice the Somersetshire plan of having a copper or iron holder, 6 in. long, with a spike at one end by which it can be carried or stuck in a loop of the cap, the candle being held the other end by two springs or cheeks; then the rude Mexican lantern, the Saxon 'blend' can be worked into a button hole. For the officers there is a pane of glass to shield the light from draughts — here, the candle is carried and fixed by a little wet clay.

The amount of candles given out varies in different mines, the management supplying the men at a fixed price. In some districts 1 lb of candles per week is allowed, in Cornwall generally 1½ to 2 lbs for 6 shifts of 8 hrs each. On the continent candles objected to, for the great waste, especially in the deeper mines, owing to the high temperature. In the collieries men will often obstruct the ventilation to prevent their candles from sweating.

Lamps, like the old Roman one, fed with tallow are retained sometimes on the continent. Oil lamps now substituted. In Scotland very small ones costing 2½d each. Fireflies in a bottle have been used in Brazil — decomposed fish also used for its phosphorescent light. Another plan was to reflect sunlight by a combination of mirrors. "The miners friend" — a steel mill (Speddings) was the cause of several explosions. In 1815, Dr Clanny, G. Stephenson, and Sir H. Davey devised safety lamps.

The Davey lamp —

Dr Pereira showed that a flame can be forced out so as to light gas.

The Stephenson or Geordie lamp.

The Clanny lamp.

The Boty lamp – one of the few allowed by the Belgian government – is like a Clanny but the feed air is admitted below as in Stephenson's.

Mueseler – mainly used in Belgium – in 1862 20,000 were in use – and no accident.

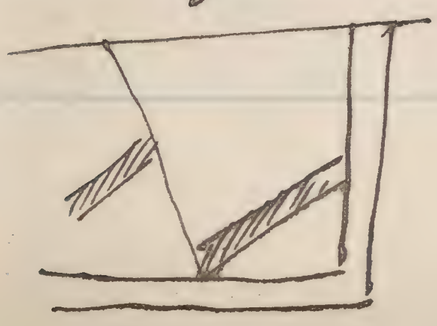
Davy's gauze had 28 aperture to the linear inch. 784 to a sq. in.

Many different means for locking the lamps, as common padlock, Belgian method by a pin of lead stamped at the office, and only opened by breaking the pin.

Mr Dubrulles' plan – if top is attempted to be removed a screw pulls the wick down, and extinguishes the lamp. but in this case a man has only to put a few matches in his pocket and pass undetected.

The best method, is, the top of the lamp can only be unscrewed – when placed on the poles of a large horse shoe magnet, kept in the office, it is locked at other times by an iron catch.

XXIV. Looking on a section of a mine, we see that many of the workings are more or less horizontal openings. called <u>levels</u>. The adit level opens upon some valley and which are pushed forward free of water and drain the whole ground above. When there are indications of mineral on a hill side, explore by an adit level, so as to drain subsequent workings above. If ore lower down is indicated drive a second adit. In Derbyshire adit level is termed "**sough**" — N. Staffordshire "gutter" Fr. galleries d'ecoulement. Ger. stollen. The inner extremity is called the 'end' in the W, 'forebreast' in the N of Eng. Ger. ort — the other extremity is the 'mouth' For galleries below the drainage level other terms are used, drift, road, heading and way drift — Ger. strecke — in Austria lauf. Another class of galleries are the cross cuts — in the collieries especially in faulty ground, and when a shaft is being sunk to intersect a lode at a certain point cross cuts are driven out from the shaft to the lode at intervals



In fig. the working would be readily drained.

Such galleries are termed 'stone drifts' in collieries
Other terms for cross cuts are cut-outs, drifts,
branch (Somersetshire) tunnels, Fr. galleries à travers bancs,
ger. Querschlag. In some galleries the rise or
dip may be 8°, 10° or 15°. Such are in Lancashire
upthrows, or downthrows, or jig brows, cross heading
Yorkshire bordgates. These level vary in size according
to their purpose, and the materials through which they
are driven. Grouping under 7 heads.

1. exploring levels and timberways
2. ventilating levels or air-ways
3. Main levels, roads or rolley ways.
4. Galleries for introducing water into mine to work
   machinery (as at the Ecton mine)
5. Drainage levels or adits.
6. Special adits to drain large districts
7. Special levels sometimes used as canals.

In a metal mine a level is from 2½' to 4' wide
and high enough to walk upright.

In stratified rocks levels are rectangular, wider than high - where roof is good, wide enough for a double road way.

16.) The large adits are often 8 to 12 ft high × 5 to 8 ft wide.

The great adits to drain large districts, as the Francisci level at Schemnitz, passing under the main greenstone range for 1571 fathoms without the intervention of any shafts - being further carried out by means of the Joseph adit, begun in 1782 - It will be longer than the St Gothard tunnel. The county (or Gwennap) adit in Cornwall drains the ground about Redruth, the distance is right drained being not more than 30-40 fms. with its branches, it is 30 miles long.

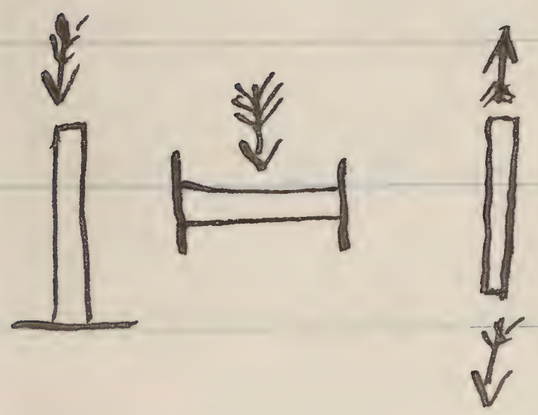
Ernest August adit, Clausthal, 18 miles long was carried out in 13 years.

XXV. Expense of driving levels.

if the rock be soft, £2 or £3 per fathom, Generally in metal mines £8, £10 or £15 per fathom, with special difficulties may even go up to £80

Almost universally you have in some part of the mine to support the workings, the question arises whether this shall be done by putting in timber or masonry or brickwork. Timber preferred, owing to the facility with which it can be introduced into the mine, and replaced from time to time. Sometimes special timbermen are employed, or men may be trusted to set their own timber.

The price of timber varies according to geographical circumstances. The strain may fall in different ways, the wood should be able to resist compression where the weight rests on it above and tends to crush the fibres together. A second kind of strain is that where, having a fixed and firm support on each side, the object is to resist transverse action on the fibre which tends to break it across. The 3rd case is that where you have the timber resisting the strain in opposite directions where the tendency is to tear the fibres asunder as in pump rods.



Fir and pine are used most largely, because of

the regularity of growth, facility, of cutting, and of carrying into the mine. Many varieties are also light, cheap, straight and tolerably durable.
The larch (Pinus laryx) most largely preferred.
Spruce (Abres excelsa) inferior to the larch, but superior to the Silver fir (Pinus abres). The Scotch fir (Pinus sylvestris) varies according to where it was grown. From Scotland not so good as from the Baltic. The oak, excellent strength and durability, greater expense in buying and fashioning, only used where great trust-worthiness is required, as in shafts. Smaller branches often very valuable.
Beech is sometimes used, somewhat brittle.
Birch more so. The Spanish Chestnut stands extremely well.

Timbering (ger Zimmerung)

27. Expenses of timbering very great, but fortunately in most of our metal and coal mines, the workings may be secured with a moderate out-lay. Necessary to see if we get the most suitable timber at the lowest price, 2ndly - that it is cut and placed properly.

In some districts dry rot sleges the timber that it has to be replaced in a few months. A great deal has been done with single props, as in coal mines on the longwall system. In one colliery 1200 dozen of single props were used up in a fortnight.

The roof along the face where the men are working must be supported. On the top of the singleprop is placed a small headpiece for spreading the surface over which distance is to take place - 12"-14" long and 3" to 4" thick. According to the nature of the ground timber may have to be put in at distances of 3 or 4 ft, sometimes longer intervals, or not at all.

Points to be taken into consideration in determining the manner and position in which the timber shall be set. 1st. the joints which run through

the rock, if they run parallel and some distance apart, in moderately strong ground there will be little difficulty with the props. If they run in transverse directions, crossing one another and cutting up the ground into fragments, which have no bearing on the sides of the excavation there is great danger of such pieces falling out. Or the measures forming the roof may be such that they can not be trusted after they have been open a short time, and must be timbered or cut down till a rock like sandstone is reached. The most dangerous things in the roof are the bases of stems of sigillaria or other fossil trees.

Stempels (Germany) Stull pieces (W. of England) are a class of props. The hanging wall of a lode may have to be kept up by means of a stull piece. A hitch or notch will be cut in one side of the footwall to a depth varying according to the nature of the rock. One end of the stull piece will be placed

in this notch, the other rests against the opposite wall, a head piece being introduced varying in thickness from a plank to 6" thick and in size to some feet in length. The head piece equalizes the pressure, they will be placed at intervals of 2 ft in bad ground, 3 ft in ordinary, 4 ft in firmer ground.

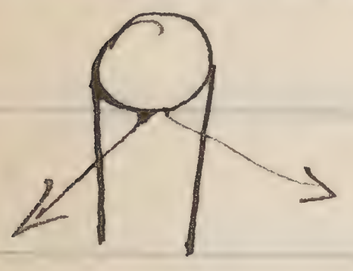
For most mining purposes the timber is round. but in Cornwall imported square timber is used.

Often the single prop will be pulled away by an apparatus like a boat hook, or a hook & chain from a distance.

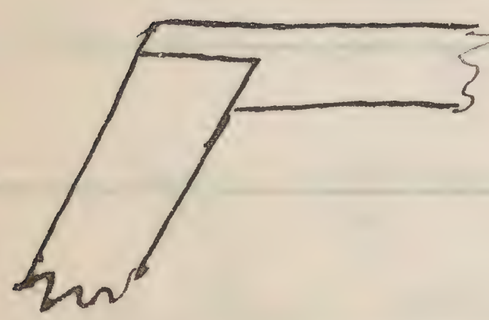
In stull pieces the only secure method of holding the timber together is by friction alone and no cuts should be made, or nails driven into it.

In some cases of military mining four planks are placed forming a vertical rectangular frame. The method may be useful in ordinary mining when required only temporarily.

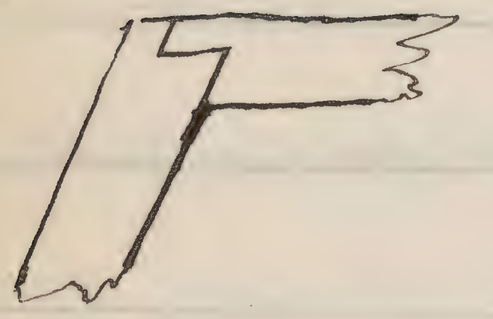
The Question of Joints — with round timber either to cut a flat face on the end of the top piece to rest on the end face of the vertical piece, or leaving the cap piece entire to hollow out the vertical piece. The cap must be cut



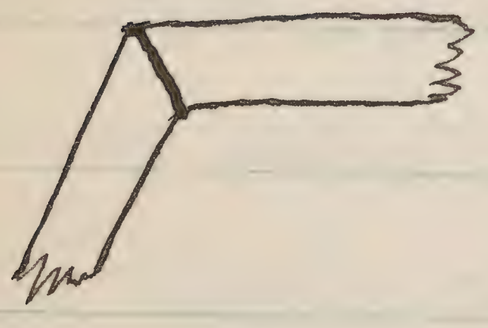
not to throw a strain in the direction of the arrows. These pieces together form a doorway in the N. a drainage in W.



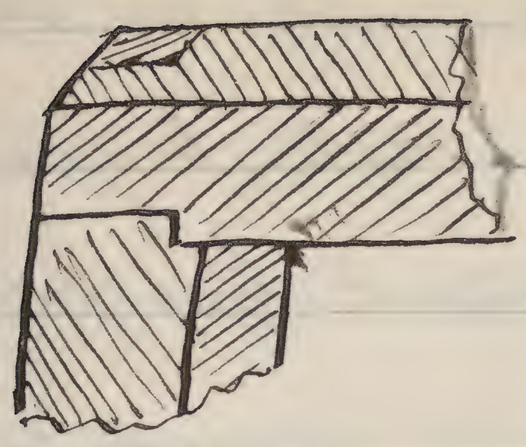
— Where the pressure is partly from above and partly from the sides the cap piece is reduce by about 1/3 its thickness



Where the main pressure is from the sides the cap piece may be reduced to $\frac{2}{3}$ of its thickness



In S. of Europe the cap piece and leg have assumed a wedge like form; very dangerous if there is any probability of the legs moving sideways.



An excellent form used in Cornwall – Since with a joint used there a slight movement in any direction is possible, without a risk of the pieces giving way. These frames may give 3 ft in the clear, above 5 ft below, with a height of 6 ft – 7 ft from the cap to the floor.

If the ground is such that you cannot leave open the space between two successive frames, horizontal planks placed behind or half round timber with the flat side next the wall

And in some cases horizontal or sole pieces may be necessary where the pressure forces the legs into the floor as e.g. into the clay under the coal. In metal mines, if the floor is not strong and you have to work up to it from below, you may let the transverse sole pieces into the wall or you may use long[1] sole pieces.

27. Avoid notching or cutting the timber, so as to put it together with nails or spikes, all being methods tending to destroy the strength and tenacity of the fibres, and thus diminish the amount of resistance the timber ought to bear. When curved timber is used it should be placed so that the pressure acts on the convexity of the curve.

Timber from wrecks may be used.

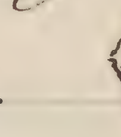
No hollow space should be left behind where the framework of the timber is lined with boards.

In working stratified deposits inclined at an angle, the timber should be placed at right angles to the direction of the gallery.

Timbering of larger spaces. The difficulty of timbering of wide lodes may be sometimes avoided by occupying only a small portion of the lode for levels, filling up the rest with broken stone.

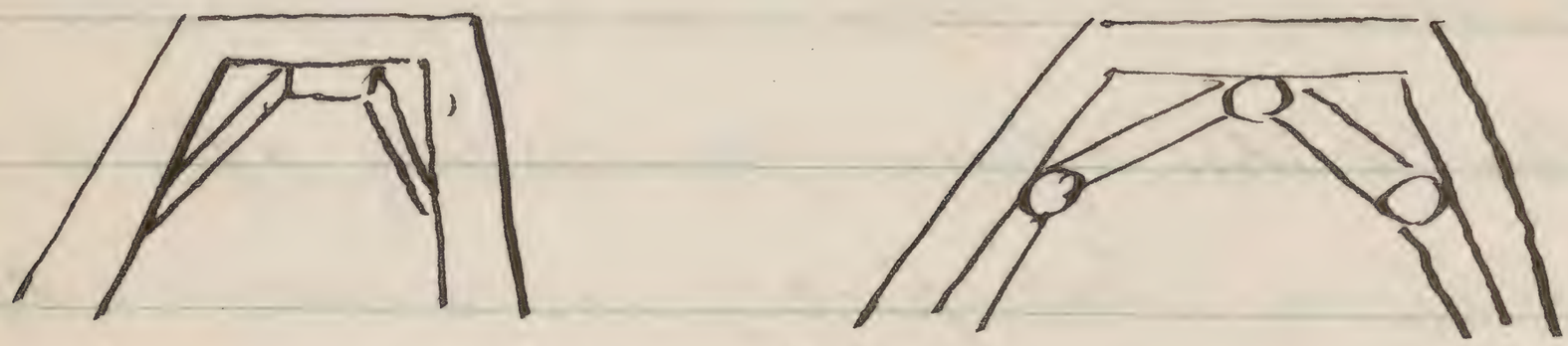
In the salt mines, taking the form of level best adapted to resist pressure it has been proposed to line the whole with blocks of wood, fitted

together like masonry, The expense was too great. In the Great Comstock lode they have adopted a form of level much like the "old mens", they use very thick timber, 8-13 in Square, carefully jointed together, the entire frame consisting of a cap piece, sole piece, and two pieces on each side. It is said that this is the only form of timbering which has been at all successful in some of the mines, especially with the addition of strong lagging behind, sometimes 2-3 in. thick.



In some German mines, where a considerable length of ~~Cap~~ is used, and mostly where the lodes are very vertical, And you want to avoid resting the cap piece on the floor, it may be supported by struts pitched against the walls. In some instances again the cap may be used in two pieces, as being less expensive, each piece resting on a long piece down the centre, the latter being supported by struts as before. In

S. of France, in addition to the long. piece supporting the cap, there are similar pieces along the walls and these have struts between them.



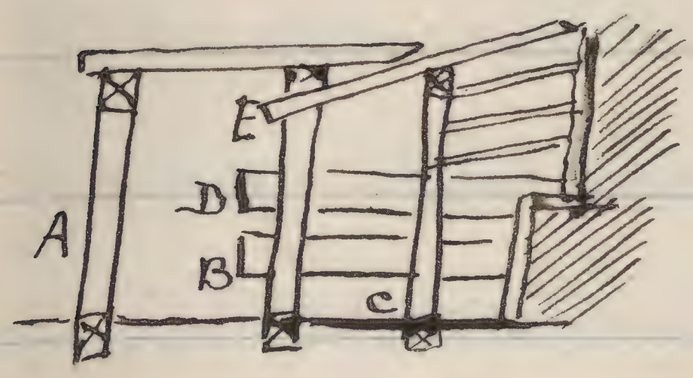
In other cases for the purpose of getting more head room there is a smaller cap piece at top between the side struts

Another variety of timbering where the lode is 24 ft
broad is as follows,— the leading point to begin
with is to have a sole piece let well into the
walls of the lode to a depth of 12-18 in
resting therefor on a kind of bracket; this piece
is of red pine 18 in. square. Footed on this sole
piece are two pieces of 18 in. timber, which
meet together at an angle above, at which
point there is placed a long piece, sometimes
three are additionally strengthened from below
by other pieces within and then by a transverse
bar, and as they have to support a strong
weight of attle, often 10-50 tons, strong 3 in planks
are usually put in Sometimes these pieces
are made compound and held together by
strong iron clamps

Cast iron props were recommended for use
25 yrs ago in some Yorkshire collieries.
In N of England iron props in two pieces with
sliding joint

Wrought iron used in some Saxon colleries, where the pressure was so great as to destroy everything else.

28 Driving through difficult ground - "Spilling" -
Ger. getriebe arbeit - Fr. palplanche.



Spilling by means of laths
The sets (A B C) consists of legs and
a cap piece, usually placed on
lower transverse pieces, and where
the ground is very fluid planks are placed below
Planks are driven forward behind the sets (D)
close together in bad ground or in other cases leaving
intervals between which are filled with moss
The planks are driven slightly outwards, at an angle
of 12° or 15°, the pressure of the sides gradually
bringing them close up to the sets - (planks,
5-8/t long, often 3in. thick. Upper laths are similarly
driven (E) inclined 15° or 20°, the pressure gradually
bringing them down on the cap pieces, and this
pressing down will again be hindered to some
extent by keeping the laths to a sharp edge.
The forebreast is supported by planks strutted
against the first set, if the level is large, or

the ground very watery or of soft sand, in ordinary ground no special protection will be needed in front. The breast is advanced by taking out the boards in succession from the top downwards and advancing each a certain distance. The object is to get a transverse sole piece to the set C as soon as possible, so as to be obliged to remove as little material as possible, moss is put in and pressed down by the timber and the whole is kept down by a strut from the roof till it can be properly secured. The alternate sets (as B) may afterwards taken out, leaving the lattes resting on A and C.

The disadvantage of this method is that the removal of large masses of loose material leaves cavities behind the timbering and the sudden shock due to falling of pieces of rock into these cavities may fracture the timber.

In Belgium – the principle is that instead of removing the material you force it forward before you. The levels are timbered as in the olden system & the planks at the top of the sides are similarly driven forward, but the floor is different. The floor is driven full of pickets (like conical wedges) 10"–12" long, intended to be permanent. The face is also filled with these pickets, somewhat longer, 14"–15", and 4"–5" diam. These face pickets are constantly being driven forward. The faces of the pickets becoming crushed by beating fill up the space completely.

In driving the Thames tunnel Brunel adopted a method similar to Spilling.

Masonry — stonework or brickwork

Walling objected to, great expense, difficulty of introducing the materials into the mine, danger and difficulty of the preparation. In S. W districts walling or arching is very little in use — in metal mines N of England and in our colliery districts it is much employed. Carried to perfection on the continent.

Among the suit-able materials may be mentioned many of the older rocks, which split parallel to the planes of stratification, ex- the sandstones of the coal measures and mountain limestone series, these are much used in Durham, Forest of Dean etc. Micaschists, various hornblendic rocks and clay slates may be used, but their joints must be looked to. Granite rarely, but has been used for arched levels in the Tresavean mine.

Empty spaces must not be left behind the wallings, they should be packed with attle,

When the London sewers were being constructed, it was a question whether the oval or elliptical form is the one of greatest strength. The oval is especially suitable when you want the greatest space at the bottom, and you can take it in many different proportions.

Sinking of shafts - (F. puits or bure - Ger Schacht)
Of the various shafts the 'sump' shaft is the deepest sometimes called the engine shaft.
The shaft for winding is the "whim" shaft.
in this shaft it may be necessary to pump as well, either by a separate engine or by horizontal rods from the sump shaft, in the latter case it is a "flat rod shaft". Winzes are also sunk.
German terms. main shaft - Haupt-schacht
drawing or highest shaft Ford-schacht -
engine shaft - Kunst-schacht - air shaft Licht-loch-schacht. Shafts may be perpendicular or inclined.
As regards the form of section, the rectangular is most common in metal mines, and used in some collieries (Pembrokeshire and Scotland) and in many continental ones
Circular most common in Great Britain, elliptical in S. Wales - In Belgium polygonal, with 16 or 20 sides

The deepest mine at present is that of Przibram. In a coal mine at Charleroi Belgium - is 1000 mètres deep.

If the lode inclines considerably from the perpendicular the shaft may be sunk in the lode rather than in dead ground - "inclined," "oblique" or "underlay" shafts - to perpendicular shafts the term "right" is applied.

At the Tresavean mine the shaft intersects the lode at a depth of 250 fms.

The size of shafts vary very much _ The older ones very small (Collins near Bath 4 -6ft in diam)
(old tin mines Cornwall _ 3ft × 2ft)
At the present day in metal mines.
6 × 5ft or 8 × 5ft or 8 × 6ft and engine shafts for pumping & for men 11, 12 or 13ft × 6 or 8ft.
In Hungary and the Harz 5ft wide × 20ft long
In Cornstock district 20-24ft long × 4-6ft wide.
In collieries 30 yrs ago 5-8ft in diam, now 14-20ft in diam. Elliptical shafts of S. Wales 22ft long × 16ft broad.

A lode coming up the side of the hill,
If a lode dips with the hill, the shaft will be put down on the foot-wall side of the hill, to intersect the lode at a certain depth _ But if against the hill, there will be a choice of 3 methods, either to sink in the lode itself, or to sink in the higher ground a perpendicular shaft to intersect the lode, or one on the foot-wall side and drive out cross cuts.
In the 2nd case the shaft would have to be larger, the sinking is more expensive than driving.

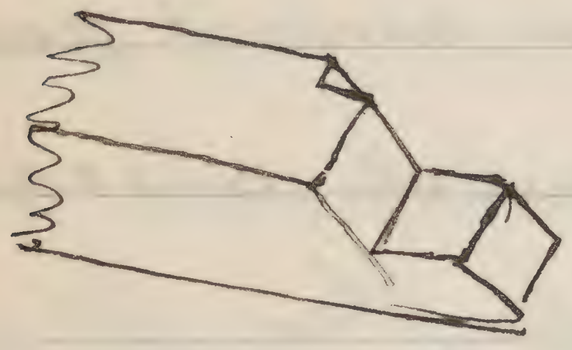
If large quantities of ore are extracted, too, the shaft sunk in the lode itself will be sure to succumb. That on the hanging wall side would require to be extensively supported, that on the foot wall side would not be affected. So that there are more reasons for sinking on the foot wall side of the lode, although the lode dips away from the shaft more than at first sight would be imagined.

Timber is generally adopted in the first instance for securing shafts.

For the method of "casing" - planks 10"-11" wide are taken, are slightly urged or a small piece is taken out of the side of one and checked to the thickness of the other, so that they fit together. In this way a frame is made up and these frames may be placed at distances equal to the breadth of the planks in ordinary ground, in bad ground closer together, while in running sand they have to be placed quite close together.

In Scotch coal districts, pits 20 ft long are protected by "barring", where planks of about 4 in. thick are made into frames, but are checked only to a small depth ($\frac{1}{2}$ in.) so as to make a joint and then the angles strengthened by means of corner pieces.

The joints used in Cornwall - are very excellent, give more trouble in cutting but are very firm.



Most remarkable timbering of late years in the Cornstock district.

In certain parts of mines, the timber is rapidly affected by <u>dry rot</u>, which will generally be found associated with a heavy atmosphere & a great degree of warmth. It cannot always be detected on the surface but the timber requires to be scooped or tested by the hammer - this must occasionally done. When decomposition of minerals is going on rapidly the timbers should be protected by better ventilation. Where you have a fresh atmosphere and water trickling down the timbers may last a long time.

The mineral should not be allowed to accumulate in the levels as it checks ventilation. and impedes the passage about the mine.

In some cases, especially where the ground is worked by tut work, it would be convenient to have adjoining the shaft some means of storing the mineral. In W. of England is called a plat Where the levels opens into the shaft, for 2-6 fms back from the shaft. a stope is taken generally about the same light as the level, and the rails for the level will be continued over this stope by a frame work of timber, the material will be tipped into the space below, where it will accumulate until the drawing apparatus is ready to raise it In the Schemnitz mines the ore is separated into several classes in a large plat

Sometimes the places into which the ore falls are made to converge towards the bottom, so as to enable you to put in a door or trap

The filling can be done in this plat (Ge. Fill-or by simply running a waggon underneath and opening the door — A suitable length is 6 pms and the whole is built partly of brick and partly of stone work.

The application of masonry to the securing of shafts. The simplest case is where the shaft is put down in the lode with its sides represented by the sides of the lode. Where the material is dug out of the lode itself a great part may remain as deads to be stowed within the walls. A piece of timber is put in as a bearer (supported against a head board) and on it is stacked the stone got out of the lode. As soon as the pressure begins to be felt from the sides you have within the walls a good strong buttress to stand the pressure. Sometimes water with a little lime or FeO etc cements these lode masses into one solid mass. Usually this sort of packing is merely of dry stone, but sometimes a flat arch is thrown across with the proper abutments cut for it in the sides: (2' or 3' thick)

Where the longer sides of the shaft require to be protected, the question of walling becomes more serious. In Belgium and England where there is much clay, special curved bricks are made.

In Saxony, to secure the sides, stonework is put in on the sides in the form of successive arches, while on transverse arches atlle or loose stone with be built up (1 or 1½ fm) and then the arching repeated. The temporary timbs being removed gradually upwards as the arching proceeds. It is best to remove this altogether that no empty spaces may be left behind. Where the pressure is great on all four sides, each has been arched. Lias limestone of the district used.

In our collieries the shafts are secured with stone if there is plenty - or bricks have taken its place. The Lining of shafts much more general than it used to be. In securing circular shafts two strong balks are placed across the surface ground, with the shaft between them. Then the foundation for the timbering of the shaft itself will be by putting in of curbs or cribs - circular frames of wood, generally of segments the same size as bricks if brickwork is to follow.

These curbs used to be of oak, fitted together or simply abutting or one cut so as to overlap the other. Of late years of cast iron. Behind these a planking of 9'-10' planks is driven down and are carefully fitted together if "spilling". The curbs are held together by stringing deals or laths. The pit will be put down like this from the surface until you reach a satisfactory foundation, to base on it a lining of brickwork. At this point the shaft will be widened a little pit being sunk below for the accumulation of water during the process. Gunpowder not used in cutting so as not to injure the ground. The precautions to be taken are that the bed should be very smooth and perfect, and that between the segments of cast iron there should be thin sheets of deal, so as to give a perfect joint when pressed together. And if we are careful about not letting any water through the joints, wedges of wood will also be driven between the deals. As the walling is built up,

all hollows behind are carefully filled up.
In this manner one of the segment will be completed, then another segment in like manner below the first, and when the second casing of brickwork has been built up the bracket of ground between it and the first will gradually be removed and the lower brickwork will be built close up to the upper.
In deep shafts (as Dukinfield, Cheshire) bricks of unusual size are used - made to fit the circle - and at every 8 yds a strong coursing of stone put in for the purpose of getting a firm hold on the measures, this we may regard as a curb.
In some of the old pits a circular lining was placed on a square curb.

In some cases the masonry is put together at the surface and then lowered

The precautions which have to be taken to prevent the introduction of water into the mine shaft. "Tubbing" (or coffering)

very seldom used in the case of lodes

In stratified rocks if you can get down to some water tight bed and then put in a water tight lining, then the water in the watery beds above will circulate round the shaft but will not enter it, and the water may rise in the beds even to the surface and thus escape.

Materials used for tubbing are brick, and stone, wood, wrought iron, and cast iron.

Circular with brick and stone, often rectangular polygonal with wood, on the continent.

Triger's method of sinking - He was engaged in sinking some pits in the basin of the Loire and in sinking through the alluvial matter, found that it was not at the surface that the sand was saturated with water, but at 60'-70' deep, near the bottom of the alluvium, and that when once this was got through the sinking was comparatively easy - The upper part could be tubbed by means of a lining, generally of sheet iron at first, but the tubbing could not be forced down as in the method of pile driving. He thought that if the atmospheric pressure was forcing the water in the tub from below, if he introduced a greater pressure into the top the water could be kept back, but the difficulty was to get the men in and out with the materials which they excavated He effected this by putting an inner tube inside the outer, making it water tight above and below by means of a stuffing box. This tube has a floor at bottom, with an opening large enough for a man to pass through

the roof is similarly provided, so that the tube is divided into 3 compartments. In passing to the lower or working compartment or in removing the materials, one of the two doors of the middle compartment is always kept closed, so as to avoid as much as possible the loss of the compressed air. At first it was thought that it would be incompatible with the men working for a certain number of hours. General pressure maintained is 2-3 atmospheres, but 4¼ has been used. A pipe passing from the lower part to the surface serves for the escape of the water. In one case when they had got down to 80 ft, they could get no farther, the water would not rise in the pipe, but then, one of the men making a clumsy blow hit the pipe, and the water instantly rushed up, and they found that by carefully managing the column they could get down to much greater depths.

Many accidents to men of unsteady habits suffered most from the compressed air.

In 1850. Kind suggested to bore the shafts down from the surface like ordinary bore holes. In 1862 Chaudron invented his method of tubbing and joined Kind.
(vide Transactions of the Northern Institute of Mining Engineers 1872)

The shaft is bored by taking out a central part 4 or 5 ft. diameter, first keeping it 40'-50' ahead. then the main shaft 10 or 15 ft diam. And sometimes there is a third stage from the surface down to near the water strata lined with brickwork.
The cutter for the small hole is made of a mass of hammered iron, in the cutter itself the teeth are steel and are set in sockets in the iron so as to be replaced if anything goes wrong with them. In addition to the main cutter are 2 guides above it which keep it vertical, one of these carries horizontal cutters at each extremity, the whole apparatus weighs 5-8 tons.
As soon as this small hole is carried far enough

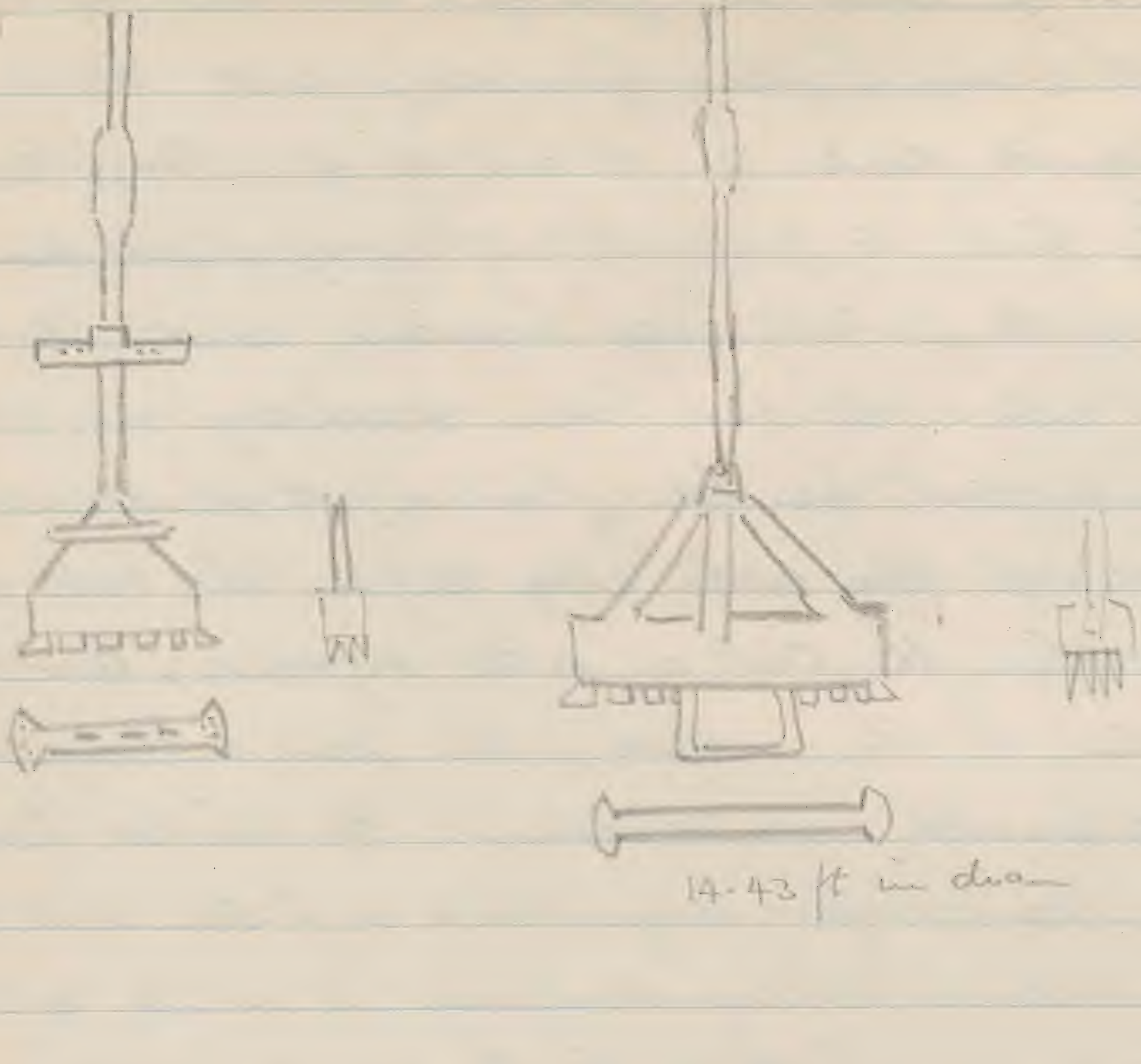
and the material withdrawn, the larger borer is used to work the larger bore hole, it has teeth like the smaller, but set on an inclined plane, so as to cut the base of the shaft sloping towards the centre. A loop in the centre of the bore which fits into the smaller shaft, serves as a guide, and the pieces of material as they are cut roll down the slope into a kibble placed in the small shaft — The apparatus weighs 16 tons.

When comes the lining — when a firm foundation is reached new tools are introduced, for the purpose of smoothing the bed for receiving the contrivance which is to secure a water tight joint. This consists of two rings, the lower flanges of which point outward, while the upper point inward and are made so that the upper can slide over the lower — Moss is placed in the outer ring of the lower piece, so that when the upper ring is forced down, the moss is compressed and fills up all the crevices.

The rings above are flanged towards the interior and strung together by rods, and the whole is lowered down by screws and strong iron rods After that a quantity of concrete is poured down the back, which soon hardens and so completely that when it has been necessary to remove a segment it has been found that concrete has kept out the water completely. The tub is of extra strength, cast in entire segments, and put together at the surface, (the joints being well leaded, and bolted _ sometimes 140 metres have been put down before any water is taken out. When the water is staunched out it is a mere matter of pumping to remove that which is in the shaft; then the men go down and make the joint still more perfected by means of a wedging curb and afterwards the shaft below can be tubbed up to the mess-box.

The cost of this method is $\frac{1}{3}$ of any other

170 yds of tubing on one shaft -



6-8 tons

14-43 ft in diam

35. "Exploitation" (fr.) is all connected with the working away of the mineral.

General rules to be kept in view through exploitation.

Remember

1. Keeping clear of water -
2 the way in which you should dispose the works with respect to the shafts and levels as to make the carriage of mineral and the haulage economical.
3. attention to Ventilation
4. Always to keep certain portions of the work in a state of advancement, making preparations for this ultimate exploitation, (most essential to the working)
5. The question of extracting the total mineral without waste to the men.
6. extra precautions needed under houses, rivers, the sea.

The general plan of laying out these operations consists in dividing the ground into a series of steps, "stoping" Method in metalliferous mines up to the end of the last century - "underhand stoping" - (Ger stossen-bau)

Overhand stoping - (Ger firsten-bau)

On comparing the two methods you see the one must be extremely economical as regards woodwork, then a large amount of wages is saved by doing away with the windlass work, & the assistance of gravity. In some cases underhand stoping must be used - ex ground with cross joints, fissures in different directions.

Again in very heavy ground, with the double handed hammer. Lastly where you have valuable minerals, in the underhand method it can fall on to a floor spread with cloths.

Difficult to get the men to change from one system to another - ex in S. of Spain.

36. In the Laxey mines the lode runs from 11-16 ft wide and it may be left open for a great distance in length and light with merely a few pieces of timber across in places, the walls being of such a character as to render this extremely safe

In the Beckwith lode, Isle of Man, 40 ft wide, the method of working consisted in taking out the ore in cross-cuts and putting in timbering as in Comstock lode. Levels were driven on each side of the lode, partly for exploration and partly because there was a good rib of ore in those parts. A cross cut was put through between the two sides and the ground between this level and the next above worked away by a system of overhand stopes, by putting in timbers over the first. Half the lode was worked at a time and usually one space of this kind was allowed to come to rest as to the pressure before another was commenced.

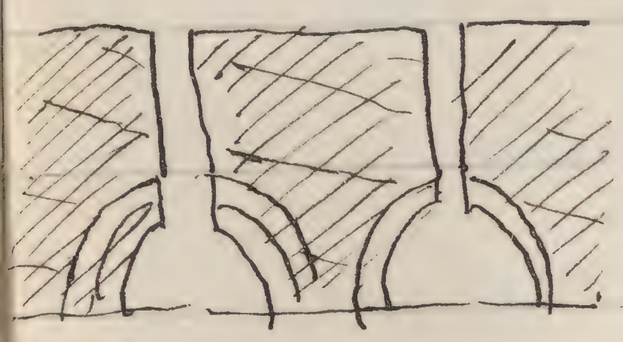
(like Wades)

The large deposits of ironstone at Ulverstone, are worked in a very similar manner

37. The coal must not be taken from too near the pits' bottom - several pillars 60 x 60 or 80 yds should be left.

"Thrust" and "creep" may be met with in coal districts and ironstone of Yorkshire. The usual way of working the ground is to take away a certain breadth of mineral, and leave another standing as a pillar, and so on. The first outset will be to drive a drift, to hold itself by its natural roof, and then see that the distance between that drift and the next is sufficient to hold the roof. When a certain quantity of ground has been taken away the pressure overhead will begin to manifest itself. If the roof be soft, some will break away, if the roof be strong and the floor strong, you have "thrust", flakes will break away from the roof and then from the pillars, When the floor is weak, as of soft indurated clay, it will tend to rise, the pillars will be thrust out of shape, and crack - this is "creep" Sometimes hundred of acres are so affected.

Bell pits in Yorkshire and Derbyshire for getting ironstone. Shafts are sunk through a moderate thickness of overlying measures, several together, at a tolerable distance apart, and as soon as the mineral is reached the the ironstone is dug out from the shale, the bottom of the pit is enlarged, till the excavation takes the form of a bell. There should be 2-3 ft of wall left for security between successive bells Sometimes the wall is holed through in places The bell pits sunk to extract the rock in Transylvania are through a cover principally of clay. On reaching the bed the pit is enlarged, the men standing on boards resting on a kind of bracket, forming a kind of level, till a vault 130-140 ft in diam. is formed. The pits are rectangular.



Bennett Hooper Brough.

Lectures on Mining.

Prof. Warington Smythe.

Royal School of Mines – 1881.

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Lecture 38. Post and stall system of working -
"bord and pillar" "stoop and room" (Scot.)
frequently employed here and on the continent.
The stone quarries of Egypt and Hindostan —
the catacombs of Rome and Paris and the
caverns of Maestricht on the same system.
At the quarries at Box near Bath, the galleries are
25 ft wide and pillars 12 ft. height of stratum is 8-20 ft.
At the salt-mine at Northwich. Cheshire, the bed is
14-15 ft thick, the openings no less than 25 yds wide.
a rib, 8 yds wide, being left between. ("Rock" mines = rock salt)
In the slate "mines", Festiniog, in Wales, chambers
are 15 yds wide and the pillars the same.
In consequence of the enormous waste of valuable
substances left in the pillars, it becomes a question
whether they are to be left as permanent
supports or left only to be removed in the future.
In some of the shallow workings in Durham
this old method may be found still, where
the coal is apt to become small in the pillars.

3 headways, or courses, are driven on the end of the coal, 30yds apart, crossed by the boards which in the shallower workings may be 4 yds broad, with a pillar of one yd. The pillars have to be widened at the end, otherwise the roadways are soon crushed. At greater depths 1, 2, nor 3 yds were enough.

In 1795, T. Barnes began "robbing" the pillars, Sometimes they took away the end of the pillar, sometimes a slice off each side, or a bord was driven through the middle or only a little of the middle was taken.

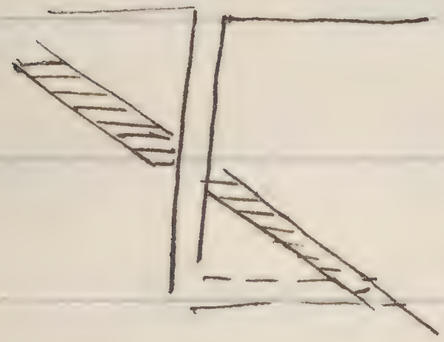
"Panel working"

Mr Buddle's plan was to divide an extensive royalty into areas, termed "panels". Between the panels will be strong ribs of coal, 40×60 yds thick, and having between them and the main lines of thoroughfare three large ribs, so that you have a mass of coal intended to be worked only towards the close of the operations, separating

the panel from the others. Meanwhile as the workings passed down from the outcrop to deeper parts of the coal field it became necessary to leave a larger mass on the first working., so that it is now common to work away $\frac{1}{3}$ of the coal at first, leaving $\frac{2}{3}$ in the pillars. Under the North Sea pillars 40 yds square are left, and in the Monkwearmouth Colliery, 300 fms deep, pillars are greater. In the Whitehaven collieries pillars used to be 10–15 yds square, now 20 yds square with openings 5 yds. wide.

39. 'Goaf' is likely to be a magazine of fire damp. In shallow ground the formation of goaf extends to the surface, but in deeper mines there is satisfactory evidence that the ground which breaks away from the roof occupies a space so much larger that, unless new conditions have packed it more closely, you may take away the pillars over many acres and yet the ground hold itself together so as not to show at the surface Workings have been opened where the pillars have been taken away under the sea.

You must not begin this pillar working near the shaft bottom as there would be great risk with lights etc



Where the seam dips at a considerable angle, it has usually been the case to sink vertical shafts and then to intersect the seam by means of cross cuts, each of these on reaching the seam has levels or drifts opened for it, a lower one for drainage

and haulage, an upper for an air way.
This pair of levels has generally a pillar 10-15 yds
between, holed through at intervals during the
working, but afterwards stopped up. Owing to the
great inclination of the seam it would be difficult
to work these bords upwards, so dips, or inclined planes
are driven from one pair of these main levels to
another (60-120 yds) The tract of coal between these
"jig-brows" is then subdivided into pillars, of
the same length as those of the North, but narrower
as they have not to stand so long. When the
coal has thus been broken up to the boundary, or
the old working, the getting of the pillars is
commenced in diagonal lines. The pillars are
cut in slices and the men protected by abundant
props and walling. Another plan is to build
up strong pieces of wood (3ft x 3ft 6 in) in pairs
placed transversely and alternately, giving a good
bearing on the roof, often used of late in the long wall
and pillar systems. By this means the greater
proportion of the coal is obtained.

In N. Wales there is in some places a magnificent roof, workings 5 yds wide, pillars only 4 yds wide. In Isle of Anglesea, roof bad, drifts 4 ft wide, pillars 6 yds.

The methods refered to are applicable to seams 3 to 8 ft thick, or in an extreme case at Whitehaven 10 or 11 ft.

40. 'Long wall' mode of working coals - ('long work')
Used for a long time in central England and on the
continent. Is the simplest and most economical method
cheaper and more coal is obtained in the round state -
safer as regards ventilation and falls from the roof, but
the drawing of the props requires most skilful
management. In the iron and coal districts of
Staffordshire and Shropshire - seams up to 6 ft thick - a
couple of pits are put down not far from one another, or
a single bratticed pit. 2 main roads, gate roads,
are driven 5-12 yds asunder communicating at intervals
and these are carried to the boundary of the coal.
In all these methods there are two courses open, either
to drive out the narrow openings to the extremity and
then work home, by 'backstroke'. Or as soon as we have
got clear of the shaft pillars we may begin to get the
coal, by "outstroke". In the former case you have to
subsist on your capital till the first part of the work is
done and it may take several years to sink the pits
and drive the two levels to the boundary.

In the other plan you have the formation of goaf near the shaft, which may endanger the shaft or main roads and be a reservoir for gas.

Along the working face the roof will be supported by timber and the distance between the face and the broken down roof will be affected in the first place by the character of the roof and in the second by the nature of the precautions to keep it up. Props will usually be placed in two lines alternating with each other and the roof supported additionally by pieces of stone packed up — of late years 'chocks' of wood are used instead, placed in pairs transversely

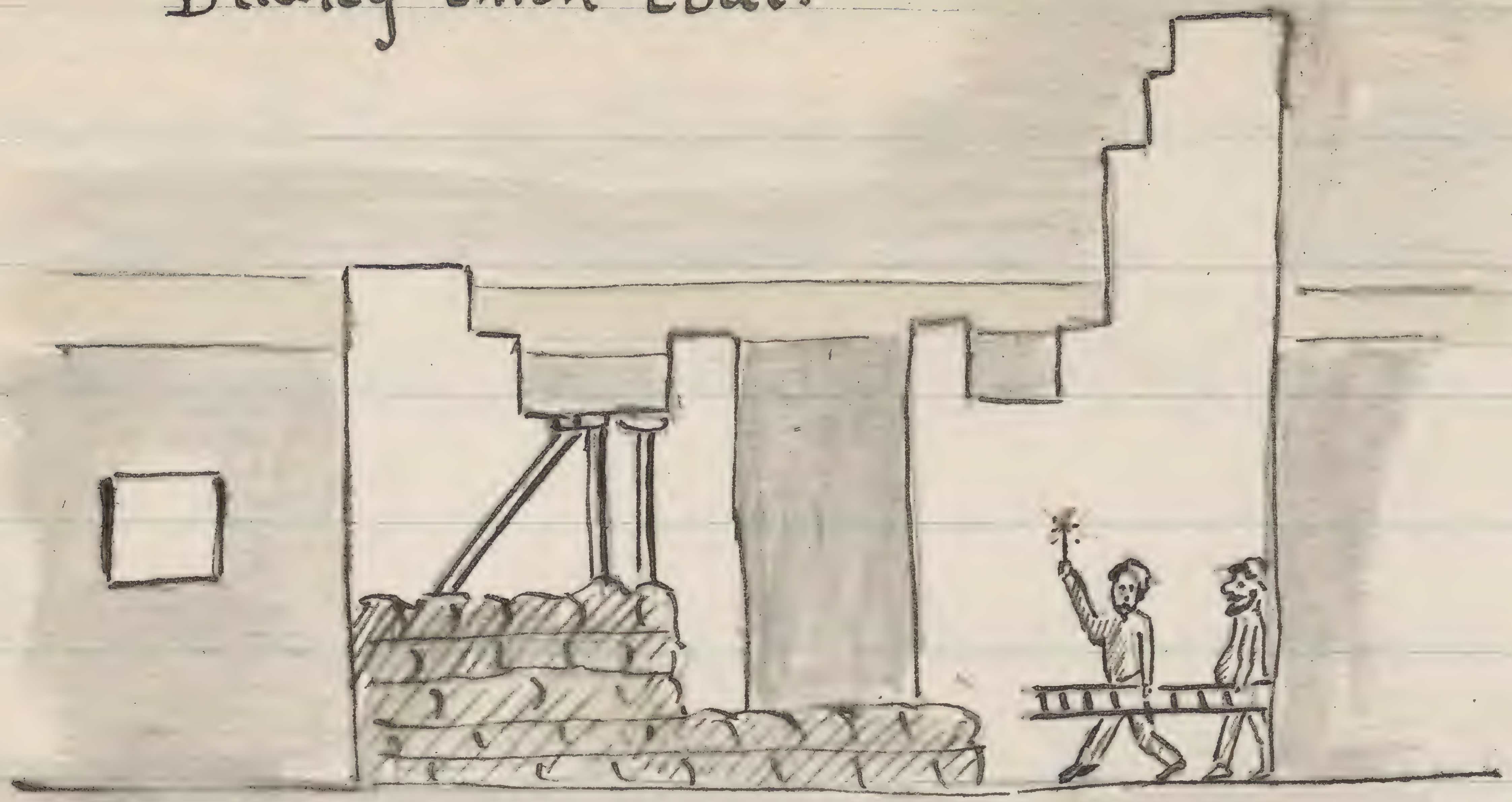
In Staffordshire and Shropshire – one set of men hole the coal, and another get it ('brushers')

41. Working seams of exceptional thickness — the methods considered are applicable up to 8 or 10 ft or even 15 ft. If above the coal there is a little shale, it is well to leave 12 or 14 in. of coal as a roof, saving much timber.

The thickest seams are in N. Staffordshire. 10 to 15 ft thick the main band at Whitehaven 11 ft — at Church Gresley, Leicestershire 9 to 14 ft. The 10 yard seam of Dudley and the thick band of anthracite in the U.S.

At Blanzy and Mont-cean the method of working by slices is adopted. (tranche)

Dudley thick coal.



× the stones are in front of the pillar & not a foundation as might appear.

Great dissatisfaction with the system of working the 10 yd. coal of S. Staffordshire. This thick seam is really composed of a no. of small seams. 2 drawbacks, loss of life, and of coal.

Smith's "mining guide". proposes to apply the long wall method, working the coal in 5 successive lifts, taking them out in a succession of stopes.

42. Removal of the broken mineral.

The system of mere carrying out the mineral, as practised in the ancient Athenian mines, and the Spanish Copper mines and now in Peru. "Apires" may bring up 300 lbs per man for 45 fathoms. In England and Scotland not many years ago coal used to be carried on the backs of women. but this was prevented by Lord Shaftesbury's act. There is one curious case now to be seen in this country — the 'billy boys' of the Forest of Dean. The billy is an oval piece of wood, shaped somewhat like a tea tray, with a sheet iron ring. This is stacked in a peculiar manner with lumps of the ore - brown haematite - each tray holding $\frac{1}{2}$ to $\frac{3}{4}$ cwt. The ore holds well together because of its roughness - At the back is an iron hook rendered flexible by a leather thong. The boys hold a candle in a cleft stick in their mouths. The reason for using this method, is the great irregularity of the repositories of ore; in following out a thread of ore belonging to a churn it may even pass backwards below the level. To have a level beneath them would not be consistent with economy and circumstances may make it impracticable to put down a wing from the level above, so the ore must be carried over the irregular ground.

Underground carriage (Ger. Förderung)

Where the coal is thin and the roof not very secure Sleds or sledges must be used — a sled being a board on a couple of iron runners, if there be underclay the facility of dragging is increased. In the last century these were pulled all the way to the pits mouth by men or horses. In German mines a tray cut out of solid wood is dragged along, or in Spain baskets if the floor is smooth.

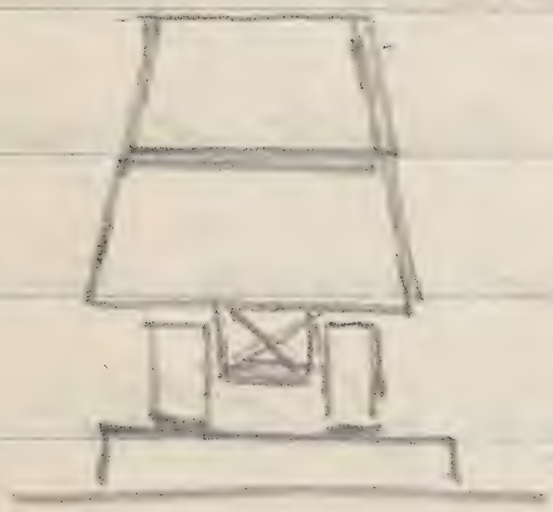
A larger sled was used on the main roads, drawn by horses. In the S. Staffordshire coal mines such a "skip" is still used — formed of 2 side pieces, 9in high × 4ft long × 3ft 10" broad. Boards are placed on the top t on which the material is stacked to the height of 3ft. An iron bow is attached to lift it and there is an iron ring at each corner to which chains can be attached.

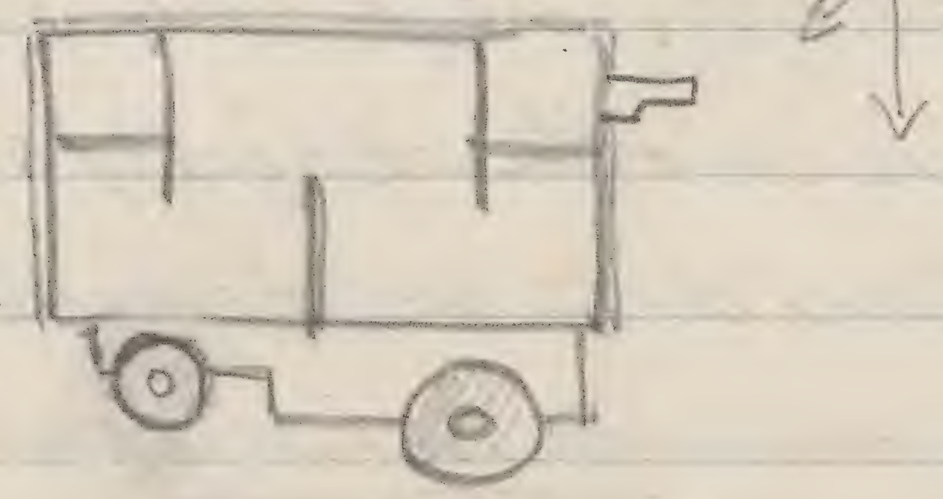
The material is kept together by iron or wooden hoops. In some cases in the iron districts these skips have a little rim and are employed for raising the ore in the shaft — This was abandoned in the N. but

is still used in the shallower pits in the W of England.
In cases where the coal is "put" by manual labour
the distance along which it is conveyed must
be contracted, so roads are often put closer
together; the coal should not be drawn more
than 15 yds. In the N. country collieries
they placed the coal in large baskets "corves"
The original 'corves' during the last century were
universal throughout the W. of England, these
baskets, were 2'6" high and had a bow
for suspension; sometimes they were dragged
along themselves, at others placed on a sled,
and dragged to the bottom of the shaft.
Substitution of "wheeled waggons" for sledges
The Germans were in advance of us in this;
wheeled carriages have been used for a very
long time — the four wheeled cart in Germany
and the (one wheeled) wheelbarrow in England.
The wheelbarrow is different from that used
by "navigators" at the surface — it is very

narrow and has the centre of gravity very low;: the work is very laborious. Agricola shows a 4 wheeled carriage still common in Germany and Hungary. the "Hund" (dogs being said to have been used for this purpose at one time)

The hund is rectangular with the sides sloping outwards a little ;- a second pair of wheels are attached to a strong piece of wood, and a second larger pair are placed almost under its centre of gravity, A wooden handle is attached at the back, and by slightly leaning on this, the two smaller front wheels are raised, at the same time that the car is propelled forwards, so that it runs only on two wheels, but stands on four.





In the German plan 2 beams are laid as rails and between them runs a pin which acts as a flange and thus they dispense with any great breadth of timber, when made without this pin (Hungarian pattern) You require a wider beam. The Hungarian workman say that it is only a bad workman who requires to be thus guided.

Cast iron tram plates were employed in 1775.

a simple iron plate with a flange to it. To diminish friction the wheels were much thinner at the periphery.

Then came the system of cast and wrought iron rails. These were first simple, a bar of iron let into a slot, on which these broad wheels ran, the wear was considerable, & the wheels were cut into, so that the rails are now like those of the surface railways. Nothing more often used than the bridge rail (S.W. railway)

(* which can be turned when empty)

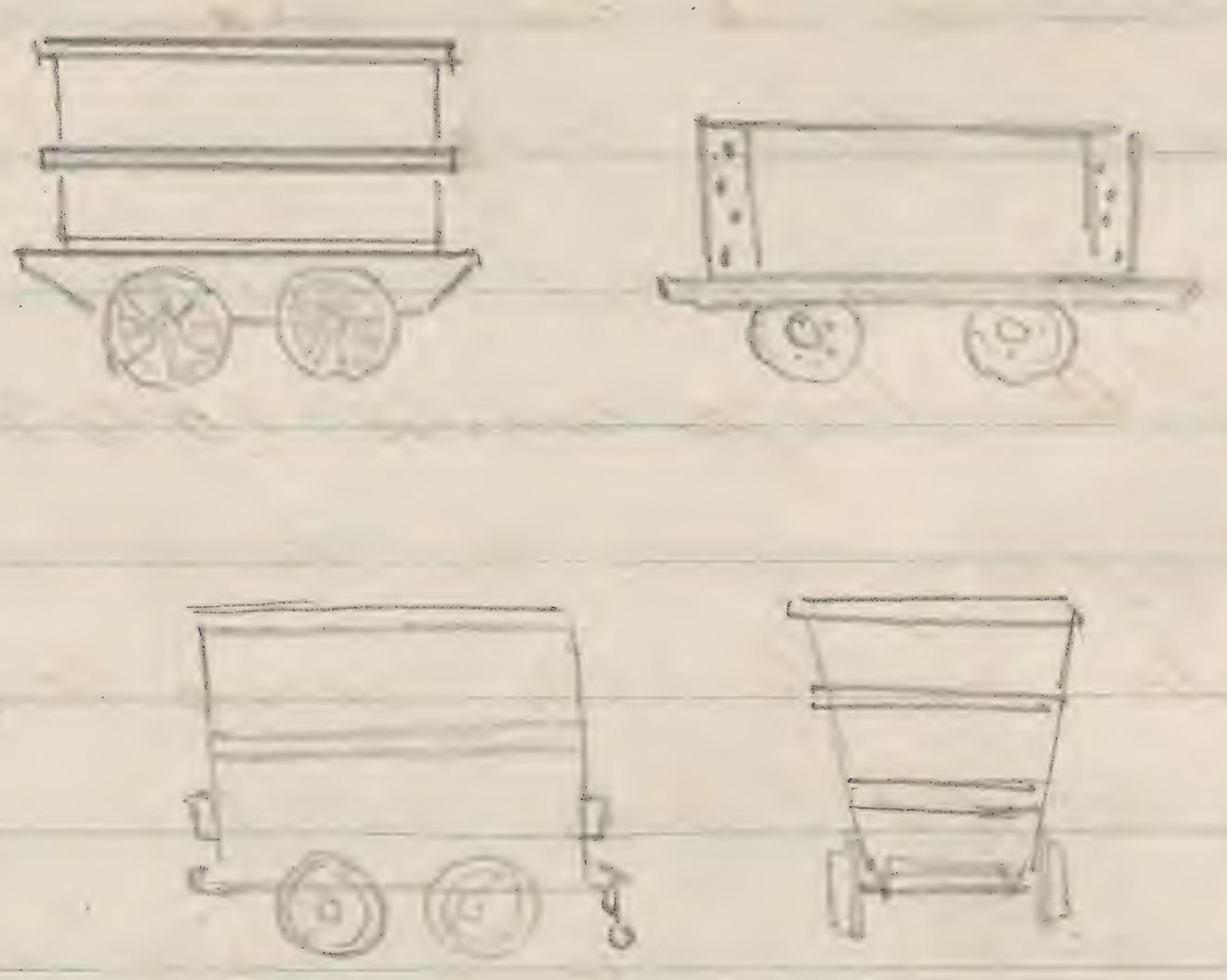
The T-headed, and double T headed are also used - Another form is a T head with a broad base with holes for spiking down the rail. These weigh 12-15 lbs per yd. or even 25 lbs. A common gauge is 2ft, in other cases 18 in. while in the ironstone mines of the N. only 12 in.

As to the form of the waggon, the first necessity is that of keeping the tub low, for convenience in filling, with coal of a largish size it is possible after filling the lower part to stack on the larger pieces and keep them in their places by iron rings.

All sorts of contrivances are adopted for tipping Ordinary tubs will be thrown into a frame, and then tipped altogether; larger sized waggons may have a door opening, by the removal of a latch, with a pin, for tipping.

Whether made of wood strengthened by iron or of sheet iron the form will be determined

to a great extent by the mode of tipping.
In coal mines where the material has
to be raised in them, the forms mostly
employed are these boxes or hutches, to
which the name tub is given, probably
having been preceded by the tub or kibble
of iron.



Colliery tubs 1 in to 4 ft

Coal waggon. 8 cwt. 4 ft to 6 ft thick

3/4" boards, angle steel $\frac{1}{2} \times \frac{3}{16}$, flat steel for knees and sides $1\frac{1}{2} \times \frac{3}{16}$.

Pedestals and axles 11/3 per set. Total cost between 25s and 30s.

43. Instead of strong boys being employed in pulling the waggons to the main roads, small ponies are used driven by younger boys. In the main roads horses draw a set of waggons. In some of the larger mines 80 to 200 horses are used. With proper roads the horse may draw 12-14 of these small tubs, in the iron mines less.

The Experiments of Mr Nicholas Wood (Trans of Nor. Inst, show that at the outside with every advantage a horse on a level road pulling an ordinary tram with edge rails would at the maximum draw 133 tons 1 mile in a day, or the common performance of an ordinary horse on a good road would be 100 tons for 1 mile per day.

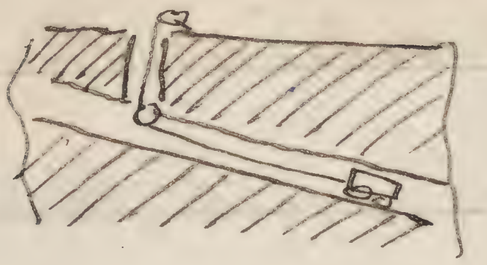
In mining work there is apt to be considerable delays. Mr Wood found the work done in the collieries much less than the maximum, with wheels of 12 in diameter only 30-50 tons per day by each horse, while with 10 in - wheels 8 or 9 in and delays, only 11-15 tons per day

The use of larger wheels with the tubs is very difficult. in S. Wales they prefer much larger sheet iron tubs, containing 1 ton, and with large wheels. Instead of the tub weighing 4 cwt and conveying 9 cwt ~~as~~ The disadvantages of these larger tubs are that they cannot always go up the shaft and if they get off the rails it takes several men to set them right.

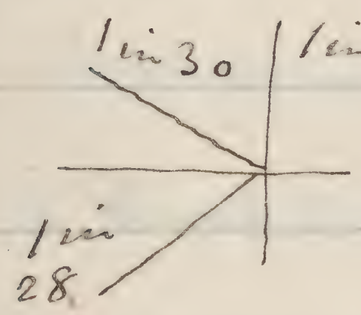
Another plan of conveying the coal to considerable distances may be used where the coal is worked to the rise — the "jig brow." At the upper end of the road is a wheel, round which a rope passes the full tubs running down one side draw up the empty tubs, the speed being regulated by a simple break.

There must be refuge holes by act of parliament — A horse can [illegible] 5-14 wagons

George Stephenson first used engine power



The engines were erected at the surface and a rope or chain passed down to the bottom and was taken down the inclined plane by a pulley. An inclination of 1 in 30 is the most suitable for main roadways with that angle the full waggons run down of themselves and draw up the empty ones below that angle you require horses or machinery. With a dip of 1 in 28 below the level you may let the empty waggons run down by themselves & they will drag out the rope for the drum but must draw them up by the engine.



employment of underground engines. An iron chain is dangerous a wire rope is best. System practised in Lancashire. For the train of waggons and a rope is substituted a chain travelling at a low rate of velocity & the tubs are brought in

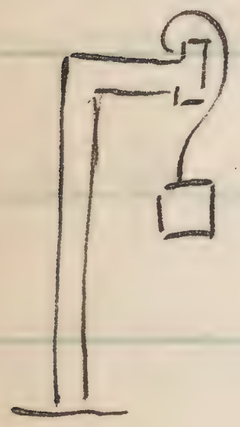
from the place of working, and the chain is thrown

over a fork at the end of each tub.

The distance between the tubs is 10-30 yds. an empty waggon may be put in here and there to keep the track off the ground.

A 3rd plan is to have an endless rope, with the waggons clipped on. The rate in these 2 systems is not more than 3 or 4 miles an hour; with the main and tail rope method, a train of 20-50 waggons with be carried at rate of 10-15 miles per hr.

This reminds one of the wire rope tramway much thought of some years ago



a wire rope passes over wooden supports a post with a cross piece at the end.

Small boxes might be thus carried along — Used in half a dozen places in England with more or less success.

In some of the larger collieries this underground work has been admirably carried on with engines working by compressed air; compressing machines at the surface. The expense of this on the engine plane is 1d to 2½d per ton per mile.

In some American mines locomotives are used, the engines 12ft x 4ft 4in, with a gauge of 3ft 6in. the engine with fuel & water weighing 1100 lbs. Locomotives are not quite compatible with ordinary ventilation.

Water conveyance. 100 yrs ago canals for mines were highly thought of. The canal may now be seen in the Bridgewater mines, Lancashire, 40 miles long at one time. 10ft wide, boats small & flat bottomed, containing about 10 tons.

Great George adit in the Hartz.

Speedwell mines, Derbyshire.

(7.7.81)

44. Travelling in the shaft.

The first plan was – opening the shaft at 20° or 30°, & cutting steps in the floor.

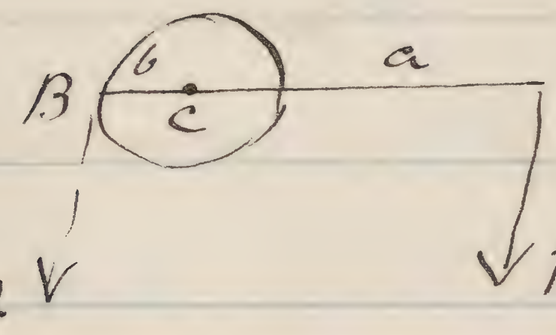
The method of letting the men down by a rope is represented by Agricola, the man setting on a cross stick at the end of the rope from the windlass. The lowering by a rope is usual. Sometimes a man will step into a kibble with one foot, leaving the other free to ward himself off the sides, in the Isle of Man and the N. the men with similarly place one foot in an iron stirrup. In Spain the men sit with one leg through a loop in the rope, the officers having the luxury of a flat rope, sometimes also a rope round his chest.

The single link chain — iron — weighs 9–15 lbs per fathom
great risk to human life — forbidden by act of parl.
to be used for raising men. In central districts
stiff or slump chains, of 3 or 4 links, with a strong
piece of wood put through, kept in place by nails,
Such chains will coil on themselves without twisting
or turning in the shaft. Weigh 10–30 lbs per yd.
A few yrs ago hempen ropes were largely used,
probably also fibres of different plants under name of hemp.
The ropes are usually of 3 strands & generally tarred.
Before 1830 flat ropes were proposed, their advantages
are steadiness in passing down the shaft and coiling
on a narrow drum, but wear & tear is very great.
In Mexico, also Belgium & France, the mexican aloe
is used, the thickness and breadth larger for same wt
of hempen rope. In 1830 iron wire proposed in
the Harz. introduced into England in 1840
The usual no. of wires is 6, sometimes hemp is placed in
the middle to fill up the spaces. Flat wire ropes
have been used in the N. with success

In 1860 steel wire proposed. iron ~~wire~~ rope costs less and lasts longer than hemp..

For raising the mineral in the shaft a windlass, (tackle or stowce) is used.

placed 30-36 in from the ground, the barrel 6in, in diam or larger if wire rope be used. Where you have a set of people raising material, it is important to know what amount of work may be done in a given time.



CB is the leverage from the barrel to which the weight Q is suspended, and P is the power acting at the extremity of the arm CA, if, then, we call CB = b and CA = a, there will be Equilibrium when P × a = Q × b or P = Qb/a.

In practice the friction of the bearing must be taken into consideration. Thus if D, equal pressure on bearing — f coefficient of friction, and r Equal radius of bearing

we have Pa = Qb + f Dr.

Walker finds that a man will work with a pressure of 12-14 lbs. on the work handle of the windlass at a velocity of 220 ft per minute, which will give us (taking 12 lbs pres.) 2640 foot-pounds. (& 3080 foot lbs)

If 2 men are raising coal from a pit 30 ft deep how much coal ought they to lift.

$$\frac{2448 \times 60 \times 8 \times 2}{2240 \times 90} = 11.6 \text{ tons}.$$

Again if we want to know what 2 men can raise in a day of 8 hrs. from a pit of 155 ft deep.
We shall get 7 tons 10 cwt 3 qrs 12 lbs.

Another variety of windlass is that with toothed wheels, where two men work on a pinion with 6 - 12 teeth, working on a larger wheel & generally in connection with a drum of greater diameter than usual.

The French method is to use a tread mill instead of handles, the amount of work (Gen. Morin) is 3176 foot lbs per minute

45. Use of horse power. With a horse in the simplest way we require a pulley over the shaft, which may be of Cast iron, 2 ft in diam. placed on ~~pulley~~ pieces of timber, which may be spread out a little so as to leave the shaft clear between the 4 legs. The rope to which the kibble is attached passes over the pulley, at the other end is attached to the horse, which walks along a horse road as long as the depth of the shaft. This is the "derrick" or "whipsey derry"

The horse whim is on the principle of the wheel and axle. The drum is 8-12 ft in. diam. the long span beam is 30-40 ft long. the horse beam is 26-36 ft. long.

The work done by a horse was determined at the rate of $2\frac{1}{2}$ miles per hour it gave the greatest pull which was 150 lbs.

220 ft. a minute × 150 lbs = 33000 ft.-lbs.

The use of water to raise the mineral. Water wheels.
The wheel is almost solely made of wood, about
a very strong wooden axis, made of a sound mass
of oak and then 2 sets of principal arms at rt.
angles to each other and embracing the main
axle. this wheel largely used by Brindley, Smeaton
The rim is 10-12 in. wide of wood, with grooves
for receiving the pieces of wood to form the boxes.
Sometimes 2 kinds of boxes inclined in opposite
directions - to make the wheel revolve one way
or the other.

For the rough purposes of mines, it is best to
have the wheels made of a solid cast iron boss.
wooden arms, and a circumference of cast
iron segments. cast with little flanges to which
the buckets can be fixed. These are often made
of sheet iron, but wood is best for mines.
The great wheel of the Laxey mine in the Isle
of Man, has a diam. of 70 feet, the axle of
this (4-5 ft broad) cost £500.

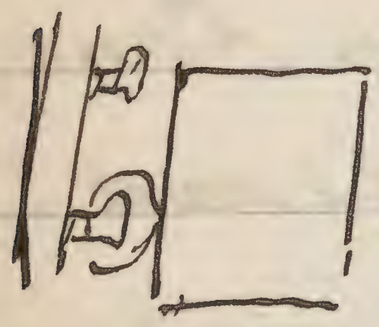
The usual size is 20-40 ft. diam. 3 ft is best breadth
Undershot wheels are rarely used for mining,
then they may require wheels 12-18 ft wide.
Before the end of the last century it was
proposed to employ a single bucket wheel, turning
continuously in one direction — and providing
for the reversal of the motion in the machinery
by a simple arrangement of Spur wheels.

XLVI. Improvements in the raising of the mineral.

1. by the German miners by guiding the kibbles in the shaft. Where the shafts were perpendicular it was frequently the case that no actual conductors were put in, but the interior of the shafts were made as smooth as possible, Sometimes thoroughly lined with smooth plank that the cove would slide down with very little friction, and if there were separate compartments for each cove a great speed could be attained, but delays with 2 or more coves in one shaft. Guides were probably first put in the inclined German shafts where the underlie was considerable & they consisted of a piece or pieces of wood, forming a kind of inclined plane on which the wheels of the kibble could run. Seen in Saxony, introduced into Cornwall. The carriages used are called "skips" in Cornwall. This may be a square box of metal (wood, Sax) with a door at the side fastened by a simple bolt and a sloping bottom, so that when brought over a waggon at the surface & the door opened the material falls out.

This runs on wheels on the inclined plane. The plane consists of a couple of long pieces of timber bolted to transverse pieces across the shaft with some arrangement for holding the two fast.

Guides in Collieries recent - Curr of Sheffield proposed 1835 Geo Stephenson thought them unnecessary. Now, commonly made of wood, pine wood generally. In a narrow pit, if the cage occupies the width, the guides will be long pieces of wood attached to the framework, more usually attached at a convenient length to buttons or cross pieces. These guides may be 4in × 3in. in section. In a well constructed shaft 2 of these bars are enough to steady the cages Wrought iron rods used in Lancashire, & could convey the signals. Another plan is to have T rails down the shaft spiked to cross buntons.



Again - wire iron rope is used, kept taut by screws or by fixing a weight of a ton or two at the bottom, rings from the cage run over them.

Cages.

Near the top and bottom of the cage small pieces of iron are placed to clasp the guides and in order that they should not become wedged they are made to curve somewhat outwards. In a simple cage, to carry one or 2 tubs, is a framework of wrought iron, with usually a short chain attached to it, an iron or wooden floor, on which are rails for the tubs to run on to, and attached to the framework above and below with be the sliding pieces which embrace the guides usually on 3 sides. According to the size of the shaft and the nature of the tubs it may be convenient to place them side by side, usually end to end, in the latter case on reaching the surface the man can push them out at once by the empty tubs that are to go down. The cages may have two decks or in some Belgian cases 6, each for a single tub the shaft being narrow.

For cages with more than one tier there should be separate stages, both at surface and below, from which to load and empty each tier, to avoid moving the cage.

Watts engines were at first used only for pumping, but within the last half century variously arranged engines have come into play for winding. Engines with horizontal cylinders are largely used and these can easily be examined, so no tall engine house need be built, and have the mechanical advantage of having the motion always in one direction, with beam engines a loss of power at each alteration. Vertical double cylinder engines are largely used esp in France & Belgium, their advantage is that they work directly on the axle of the drum without any gearing.

In collieries drums often very large.

16-25 ft diameter

In collieries of moderate dimensions one pair of ropes may be raising 500# tons in 10 hrs, sometimes 1000. With the great depth come the difficulty, for where you have a couple of ropes passing over one pulley at times you will have one load near the surface while the other is near the bottom. The great inequality of the length of the rope destroys in the two cases the balance, at one point in the shaft there was equilibrium, but throughout the greater part of it there has been an inequality of work on the two sides. The empty kibble in descending may so outweigh the full kibble that there will be a greater tendency for the former to go down with great velocity and it may be necessary to set the engine to work against it. It may be obviated to some extent by making the rope wrap round and round on itself, so that the full kibble acts at greater and greater

leverage, while the empty bubble with constantly diminishing leverage, and the work may thus be more equable throughout. Hence the introduction of flat hempen ropes, but the wear and tear is a serious ~~an~~ expense.

The use of the conical drum - first used in Hungary

The rope commences to wind on the smaller part of the drum and as the weight approaches the surface gets more on to the larger portion

Round iron or steel ropes have been used lately in conjection with it. Some of the larger drums have the slope too great and this gives a tendency for the rope to slip, which would be attended with serious results, to prevent this a flange is placed at the edge. The drums are also attended with powerful brakes.

Another plan is used for counterbalancing a heavy weight. From a small drum on the same axle a strong flat chain is carried to a

pulley placed high above the ground, and the chain passes down into a shallow shaft and is there attached to a no of heavy iron rings. This is wound in such a direction upon the drum that when the engine has its greatest task to perform — the lifting of the full weight from the bottom, with all its rope attached — the weight of the chain and iron will assist the engine, but as the engine raises the load to an easier position this heavy chain begins to subside at the bottom of the shaft and thus less and less of its weight acts on the drum. Similarly in the case of the descent the superabundance of power is employed to raise the chain again.

In Rosebridge Colliery, Lancashire, the descent of 800 yds is accomplished in 50 seconds.

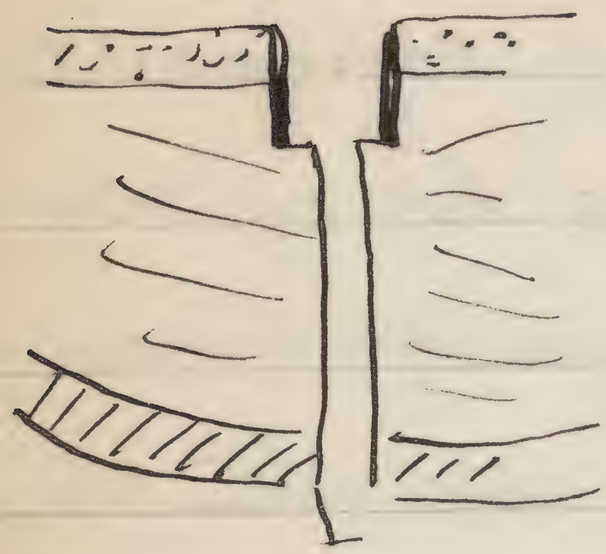
Methods to guard against the breaking of the rope, began to be proposed in 1846.
The safety cages (Fr. parachutes) have all depended on 3 different plans.
1. A pair of legs with sharp teeth, which in case of accident shall dig into the wooden guides, and support the cage, but under ordinary circumstances are kept up by the action of the rope on a pair of levers, the legs being brought into play where fracture occurs.
2. An eccentric is attached to the cage, with teeth on one side of it, if an accident occurs a spring is released which has been kept in compression and the wider toothed part of the eccentric will spring round and clutch the sides of the guides. Both these have come into play when not wanted

3. When different kinds of grips come into play by the action of a spring.

XLVII. The mouth of the shaft should be protected by means of gates, or some arrangement, to prevent men falling in in thick weather. Sometimes there are rack gates or guards round the mouth only to be removed when a cage comes up. In our metal mines the top of the shaft is usually guarded by a strong heavy door, with a string from it passing over a pulley to a counterpoise, an opening is left for the chain to go through, so that the winding may go on. This is a great stoppage to ventilation In central England a "runner" is used. On either side of the shaft for a few feet back is placed a pair of rails on which a wagon frame supporting a rectangular platform - the runner - stands when the shaft is at work but not having the weight raised, it can be left open for ventilation At other times the runner is placed over it having a slit for the chain to pass through, and the when the kibble has passed up the runner is placed under kibble lowered gently down to it & is then drawn back for the kibble to be emptied.

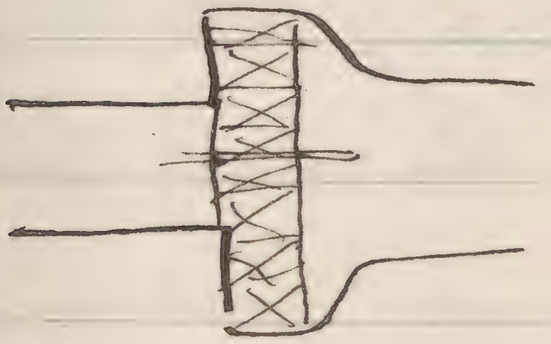
It was found necessary to guard the top of the pit during working by something which would not interrupt the ventilation, hence air frames were introduced first in South Wales. Light frames of wood are, placed over the shaft, lifted up by the cage when it comes up, and let down on to the top of the shaft as the cage descends, a long elastic bar of wood forming the bottom lath, so that the frame should not suffer too much from the concussion This has been generally replaced by the shaft door which is a little light door, placed in grooves, to run up and down, and struck open by the cage as it comes up.

The extraction of the water from the pits.



Surface water may be kept back by tubbing. In metal mining the adit will drain the ground down to its own level, if the ground be worked below it the water must be raised up to it. The important point in pumping is to make good as far as you can the damage at the surface, and then to take up all the water you can from time to time, so as to prevent it going down into the deeper workings, and you will thus gain in having to pump it from as small a depth as possible. It will generally be found that the upper pumps have to be of much larger calibre than the lower ones, the upper ones may be 16 or 18 in. in diam, the lower ones only 6 in.

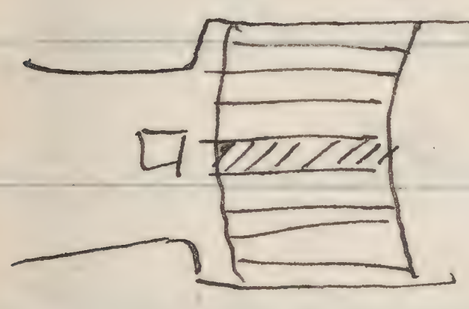
Sometimes you can shut off the water altogether by a strong watertight dam. e.g. in metal mining a cross cut may pierce into watery ground or in a colliery a stone drift from one district to another may be very wateny, you must then dam off the water. These dams are generally either of timber or stonework. A suitable spot is selected in the ground to be dammed, where the superficial area is not too great, where the ground is watertight and we can trust to its being free from fissures and where a suitable bed can be cut without blasting. A conical excavation is cut out as a bed



with a vertical shoulder, against which the timbering can abut. A series of beams are then placed in abutting against one another and having a piece of sheeting deal where it comes in contact with the rock and an opening will be left in the central part large enough

for a man to creep through. The door over this opening will be kept open while the men are at work at both sides, it is made to fit close against the man hole by means of leather. The back of these beams will be cauked full of wedges, just as in the case of tubbing and very commonly the back will be supported by planks and struts abutted against vertical or more usually horizontal props let well into the sides. A cast iron pipe passing through the dam is all this time conveying away the water which accumulates at the other side, so as not to inconvenience the men. Another precaution is necessary; to have a small iron pipe in the upper part, when the dam is completed, to allow the air to escape & leave it open for a time. When all is ready the men retire the water pipe is plugged up, and when the air has escaped the upper pipe is plugged also. and the man hole is effectually closed by the pressure of the water against the door.

The thickness of timber used will depend on the amount of pressure, if not very considerable stout planks may suffice, if great, stout logs of wood will be taken and set vertically side by side. The best of all these dams is formed in a conical piece, where a number of beams of 4 to 6 ft. long are put in and fitted up



like the stones of an arch, with the convexity towards the pressure, having a cast iron pipe in the middle just large enough for a man to get through a small hole below for the water to flow to flow from for the time being and a small pipe above for the escape of the air. Such a frame, made of a thickness of 6 ft. over a superficial surface not too large may be made to sustain very heavy columns of water. A structure of this kind made of pieces of fir well fitted together will generally be found to move considerably

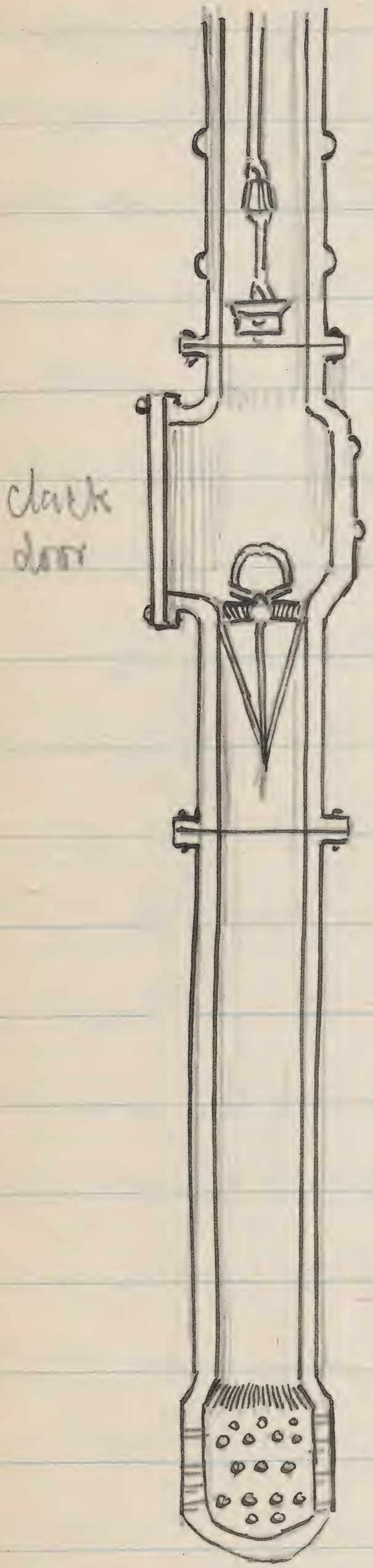
at first, when the pressure comes into play, but if well made and the conical bed well cut, the pushing forward of the mass sometimes need not alarm us.

Sometimes the more difficult task has to be performed of putting dams into shafts, they occur, however but rarely. They partake somewhat of the nature of those for levels, but require still greater attention to the cutting of the bed. They are constructed of timber or heavy masses of brickwork, usually of an arched form, and sometimes double, with clay well rammed between. In Westphalia & Belgium a good many examples, and in our own colliery districts not uncommon.

XLVIII. Pumps.

the ordinary drawing or lifting pump. a pipe, the working barrel, in which the bucket works formerly of wood, now of cast iron, or in acid wates gun metal.

Bucket or drawing lift



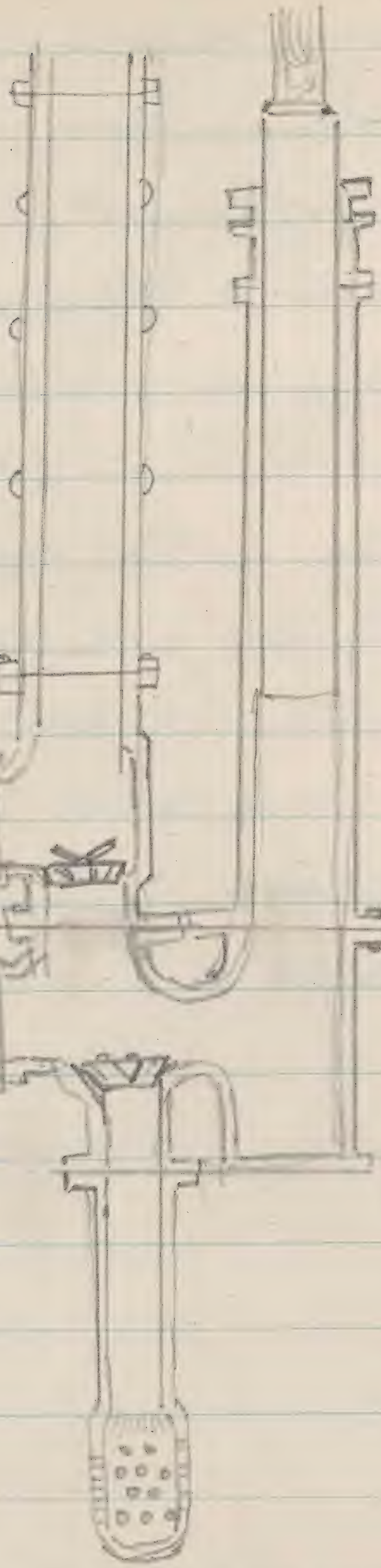
bucket in
the working
barrel

clack
door

clack or
valve piece

wind bore
or suction piece

Plunger lift



plunger
pole or
rod

stuffing box

plunger case
of bored
cast iron

50. The most convenient means for the passage of the men. Travelling in the shaft (Fahren) The first plan is to open the shaft at 20° and then cutting steps in the floor. In the salt mines of Cracow, wooden steps.
In other cases the men slide down the inclined shaft on a piece of board, holding on to a rope, by the side of this steps are cut for the passage up. The most frequent plan for metal mines is the use of ladders.
The method of letting down by a rope is represented by Agricola. In the N. of England instead of ladders they often have staples of small diameter, which near the top of the shaft, if the ground stands in walling, they will stick in some pieces of wood — Risky and fatiguing On the continent miserable ladders made by putting cross steps to a single long piece of wood, and not used in England. great strain on the chest and heart.

Ladder used for the principal travelling in mines are formed of two cheek pieces, generally rec. set at 12-14 in. apart. The steps here are generally round and thickened in the middle often of flat wood. Of late years replaced by iron, where the cold is excessive they are trying to the hands, and when much worn they may become almost as sharp as knife edges, acted on by cupreous waters, The distance asunder is 10 to 12 in. between the middle of the steps. 11 in is best.

With a suitably inclined ladder the centre of gravity of the climber falls between his feet — But with vertical ladders the C. of G. falls outside the ladder, the man is obliged to pull himself up by the muscles of his arms & chest. With inclined ladders the foot of each rests on one side of a sollar or stage on the other side is a manhole through which the head of the next ladder comes.

In a medium shaft there is no occasion to shorten the ladders too much, 2-3 fms common. To prevent the ladder swinging a strut may be placed against the wall and the side of the ladder. The soles require careful attention.

In woody countries dump ladders are used // long logs of wood with steps cut in the side, very useful for rough usage. In blasting and sinking a chain ladder is very convenient.

The question arose whether a good deal of time was not lost in getting down 300 fms by ladders, and whether the men were not subject to a good deal of fatigue and disease
In 1830 in Harty & Cornwall the man engine was devised. At work in the Harty 1839, 3 yrs later in Cornwall in the Treasavean mine. (Ger. Fahrtkunst) In the Harty (the machine

were at first only appendages of the pump rods, afterwards they were put up on a small scale with light rods to be worked on a small water wheel.
In Cornwall of solid rods 7in. at top, 5 or 6in. below. In the Harz the steps were attached by resting on a bracket, with whipped to the rope, the rods being of wire rope, strengthened at intervals by planks With 5 to 7 strokes per min. each 12ft. you could travel at the rate of 60ft per minute. In some cases the rods are single the men stepping off on to a platform at the end of the stroke, and these single rods have to be balanced as single pump rods are.

It should be worked at some distance from the engine by a system of cranks, and the rods are equilibrated by being connected by stong chains passing over a pulley.
The accidents have been rather numerous during the last few years.

5/. Ventilation. wetterlehre - wetterführung -

Besides the mere stagnation of the air, the air in a mine, is vitiated by the burning of the lamps, by the breathing of the men and horses and by the gases and smoke from the powder. Also chemical changes going on in the rock - emanations of CO_2 and fire damp.

The winges afford facilities for the natural circulation of the air

Marchant examined the air in a brown coal mine - at the mouth of an adit level he found 0. 20·52 p.c., this decreased till at a place where the lights went out it was only 15·23 p.c.

Dr Angus Smith examined the air in Manchester streets and found 4 pts of CO_2 in 10,000 air. In fogs. 6 pts - in London streets. 16 - in the Strand theatre 10 - in the Standard 32 - in mines he found in the worst case 273

in certain cases exceptional matters get into the air & in tin mines often a smell of As.

CO_2. Sp gr 1·52. - 8-10 pc make candles go out.

SH_2. s.gr. 1.191 takes fire when mingled with air - poisonous, peculiar smell.

Air - poor air due to absorption of O and the addition of CO_2.

CO. Sp gr 0·97. from a sort of process of distillation of the coal in underground furnaces.

Fire damp - CH_4. Sp gr 0·55.

52. Fire damp - or Marsh gas CH_4 - Spec. gr. 0·5·5.
(French "grisou" - Ger. "Schlagende-wette")
sometimes said to come off in a state of very great purity, but generally mixed with air. 1/3 with ordinary air will cause suffocation, with 1/7 by vol. of the air it is scarcely explosive, but will burn, while in prop. of 1 to 7 or 15 of air it is violently explosive In fiery mines it is apt to be disseminated over a very large area of the working faces and when these are wet it may be seen to exude in multitudes of little bubbles. Under these circumstances it ought always to be kept under & can always be so kept by leading a sufficiently strong ventilating current along the face. The case is different when the issue is confined to a more limited space, and where it partakes more or less, of the nature of blowers, where the gas escapes in enormous volumes, and often with great violence from fissures in the rocks

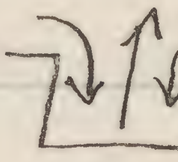
in which it has accumulated under great pressure
In some such cases no amount of ventilation
possible can render the gas harmless and unless
the people are found prepared with safety lamps
and due precautions, the most serious results
will occur.

Geo. Stephenson first showed that the evolution
of fire damp is affected by the barometer,
he remarked that when the barometer was
low some of the blowers were throwing out
great quantities of gas, but when it stood high
he found these same blowers would not only
give off no gas but in some cases even draw
the outside air in The pressure of a heavy
column of air tends to force back the gases
into the fissures and pores, whereas when
the pressure is lightened they come out in greater
force, and the increased danger must be
met by increased ventilation. You will generally
find that at the time the barometrical pressure

is taken off and the amount of danger increased, that with the increased temperature your ventilation, as far as it depends on natural causes, falls off, so that the energies of the people who have to manage the ventilation ~~fall off~~. will be doubly taxed.

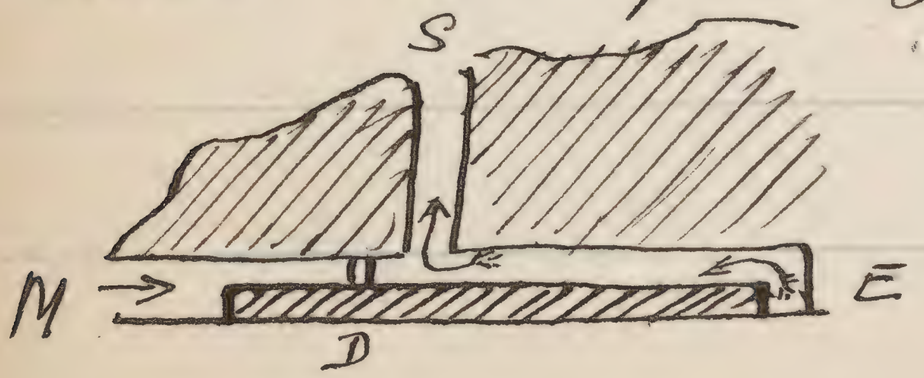
The increase of temperature as you go downwards from the surface - The general average result of Reich's (Saxony) observations was that the depth corresponding with an increase in temperature of 1°F was 76·26 ft - Mr Henwood gave the depth 66 ft - The observations of Prof J. A. Phillips at Monkwearmouth Colliery gave 57·36 ft. The experiments by Mr Bryham during the sinking of the Rosebridge Collieries where holes were bored to a depth of 3 ft in the rock at the sides and thermometers placed in and tamped gave as a general results in the lower parts of the workings 51 ft for 1°F. In the Grenelle borehole Arago found the depth to be 60 ft.

At the deep holes at Creusot, Malfredin gave 56°F
in one bore hole and 43·1 in the other.
In the deep Prussian bore hole. 67°F.
At a depth of 30-50ft below the surface
the temperature of the ground is invariable, &
just equal to the mean annual temperature
of the locality, hence going down on a cold
day it appears warm, when on a hot day, cold.
(Rosebridge at bottom 93°.
Laxey mine cooler, better ventilated
St John D'El Rey cooler)

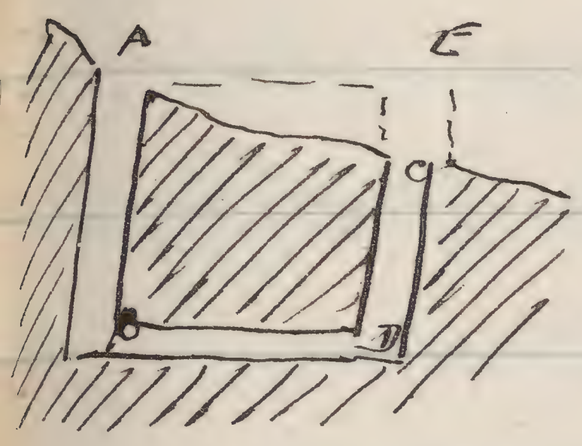
Many mines are sufficiently ventilated by natural ventilation. Eg in driving a level 50-80f a natural ventilation will be set up the air coming into the levels along the floor running as far as the end then rising and returning along the roof. Similarly in sinking a shaft the air passes down the sides and returns up the centre. In both these cases the natural ventilation is greatly assisted by the placing of a diaphragm, or lattice, horizontally in the case of the level and vertically in the case of a shaft so that the currents of air moving in opposite directions are prevented from rubbing against each other. 
Seaham colliery was sunk to 260fms with only one shaft.

53. On the small scale this principle is carried out in the use of air boxes or air pipes, usually square wooden pipes with joints fitting in to one another and placed on timbers at the top of a level or supported at one of the corners of the level, or on a large scale, 2 ft sq, on the floor; but in these latter cases it is a question whether a 2nd level ought not to be preferred and introduced. In consequence of the objections to these pipes being of wood, their liability to decay & dry rot and the fungoid growths obstructing the current and often imparting a disagreeable odour — other materials have been proposed and used e.g. Zn, wrought iron, cast iron, ~~&~~ papier mache etc.

A natural ventilation is set up where you have two openings at different levels, The current may be made to ventilate the parts beyond the shaft opening



by leading air boxes from the level between the shaft S and the mouth M of the adit and continuing them to the end, E, closing up all other communication between the shaft & the lower part of the level by the door D



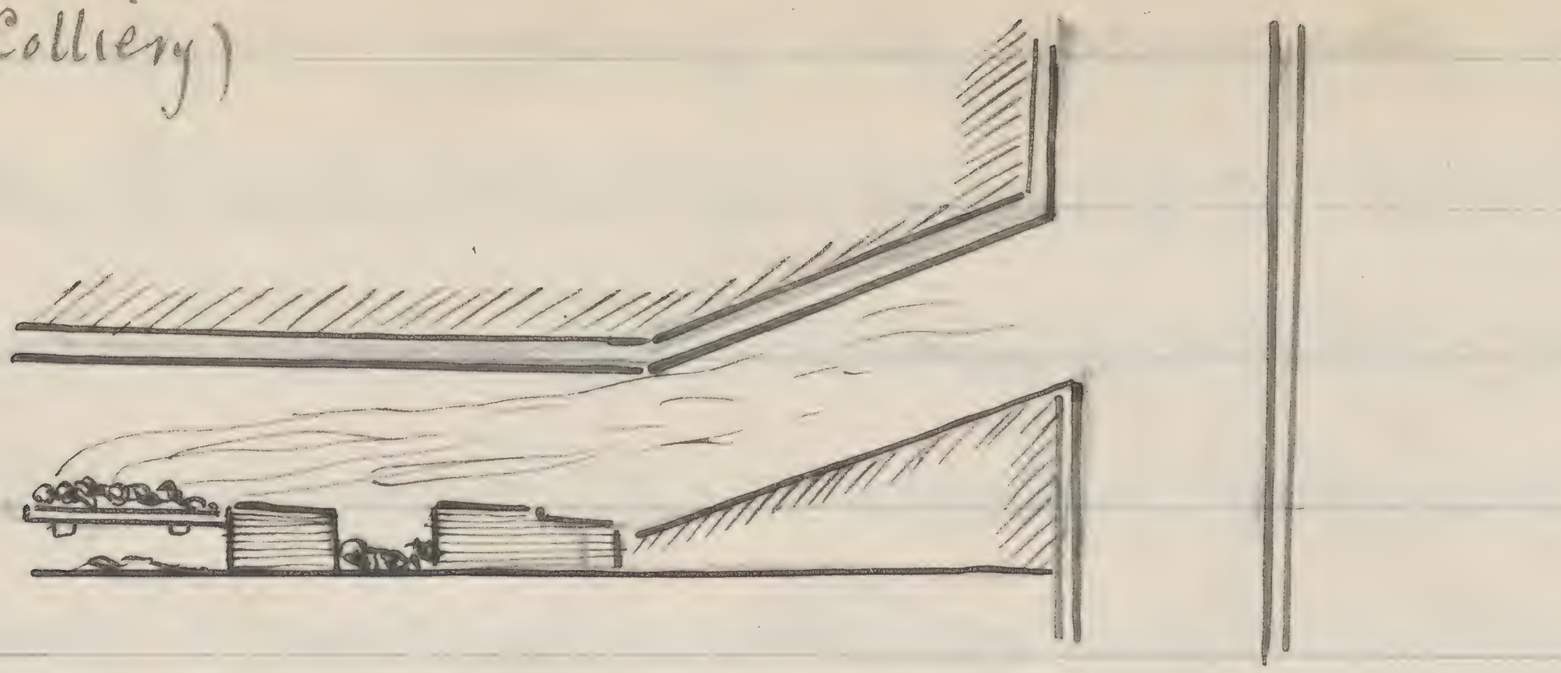
In this case on a cold winter's day the column ED will be heavier and a a current of air will set down CD & up AB. On a hot summer's day the reverse is the case. In many collieries the ground is flat and the shafts of the same level. The necessary difference of level is sometimes secured by building up a regular stack over one of the shafts. But it may be with equal shafts water dropping down one may cool the air there & produce a ventilating current. In these cases a change in the weather may cause of stagnation of the air.

N. Wood has shown that many thousand cub ft of air can be driven through by natural ventilation. Another method adopted sometimes in Flintshire is the putting up cowls so arranged that the cowl at one shaft always opens to the wind that at the other shaft being always closed to the wind, the cowls are simply constructed out of a barrel.

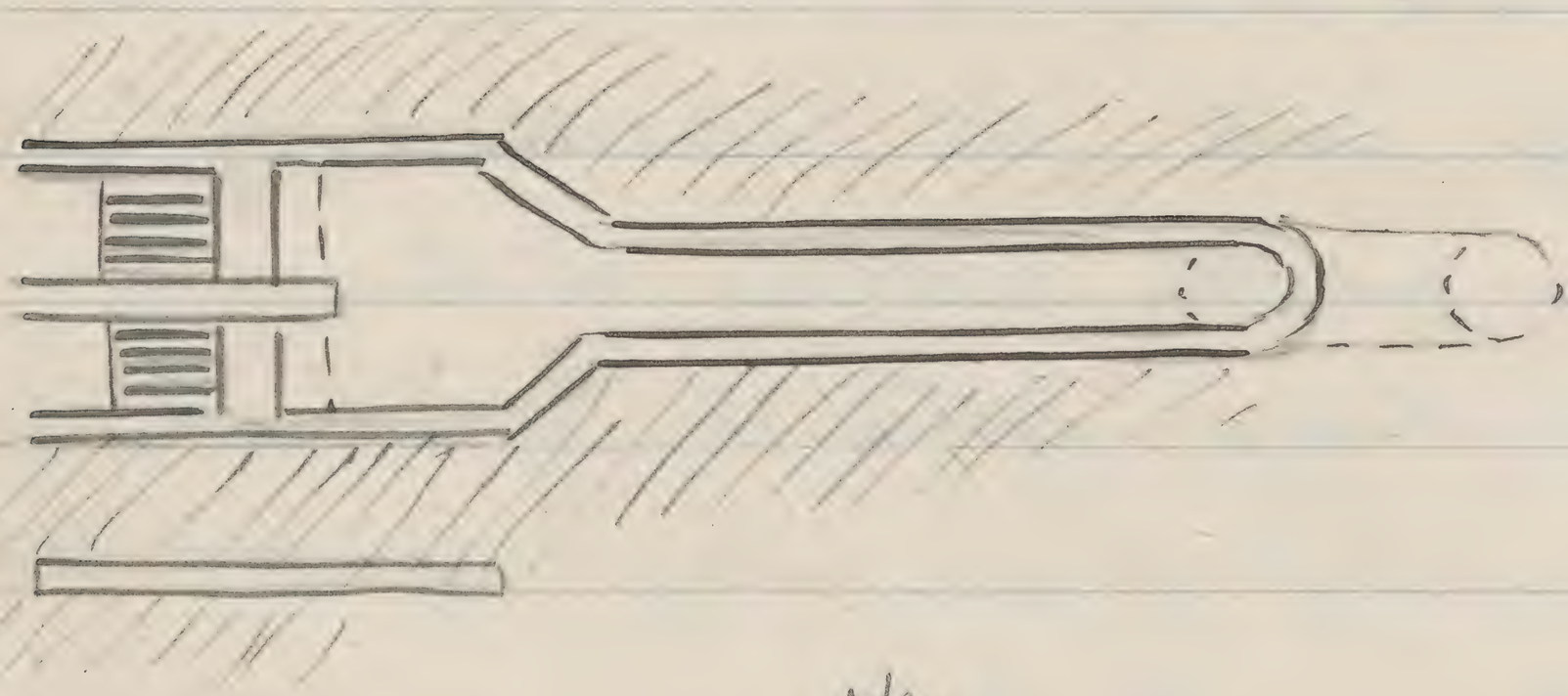
There is one method of aiding natural ventilation common in metal mines — putting in an 'air sollar' The lower part of the level is partitioned off by a floor, timbers being first laid across then these covered by close fitting planks and finally the whole made air tight by means of clay.

The use of a furnace for giving sufficient lightness to one column of air. The simplest way is to let down a frame of burning coals in the upcast shaft. A modification of this is to connect the top of the upcast with a close building, with double doors, in which is a fireplace connected with a stack. This compares very unfavourably with the method of placing the furnace at the bottom of the shaft, where you have a large column of heated air contrasting very powerfully with the weight of the column of cool air in the other shaft.

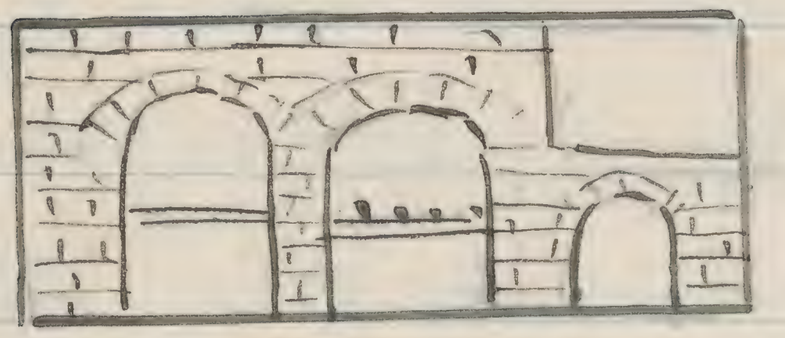
Ventilating Furnace.
(Helton Colliery)



long! section



plan.



Cross section

Bennett Hooper Brough.

Lectures on

Mining.

Prof. Warington Smythe.

Royal School of Mines. 1881.

*

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54. Sir Goldsworthy Gurney proposed that the ventilating furnace should be superseded by the use of a steam jet. Shown that it cannot be employed except under peculiar circumstances and with a great quantity of fuel. A pipe was carried and turned down the shaft, ending in a jet of $\frac{1}{4}$ in. to $\frac{1}{2}$ in. diameter and steam of high pressure was supplied, this tended to force the air down the shaft, at the other shaft a jet was turned upwards, the steam thus tending to carry the air up with it. A no. of jets employed where a greater effect was desired.

But the quantity of air got to pass into the upcast was very far surpassed by a furnace - and with a steam jet, 2 or 3 men at the fires could not work fast enough, whereas one man, perhaps unfit for laborious work, may suffice to attend to the ventilating furnace.

Among other methods we may look first at the system of falling water. The drops of water falling down a shaft mechanically force some air down. In the case of an accident, the pumps may be allowed to run over and water to fall down the shaft, & by that means a good deal of air may be got down into the mine.

The Trompe of the Pyrenees. The principle of it is - a stream of water falls through a vertical wood pipe, in the sides of which are a number of oblique holes through which the air is drawn in by the falling water. The water falls into a box or box below in which is placed a large stone or iron sheet to break up the column, there is an exit for the water in the lower part and the level of the water is always kept above this. In the upper part the air collects and can be had off by a pipe from the top to the place where it is required. Another method is that of having a pipe laid to the bottom of the shaft,

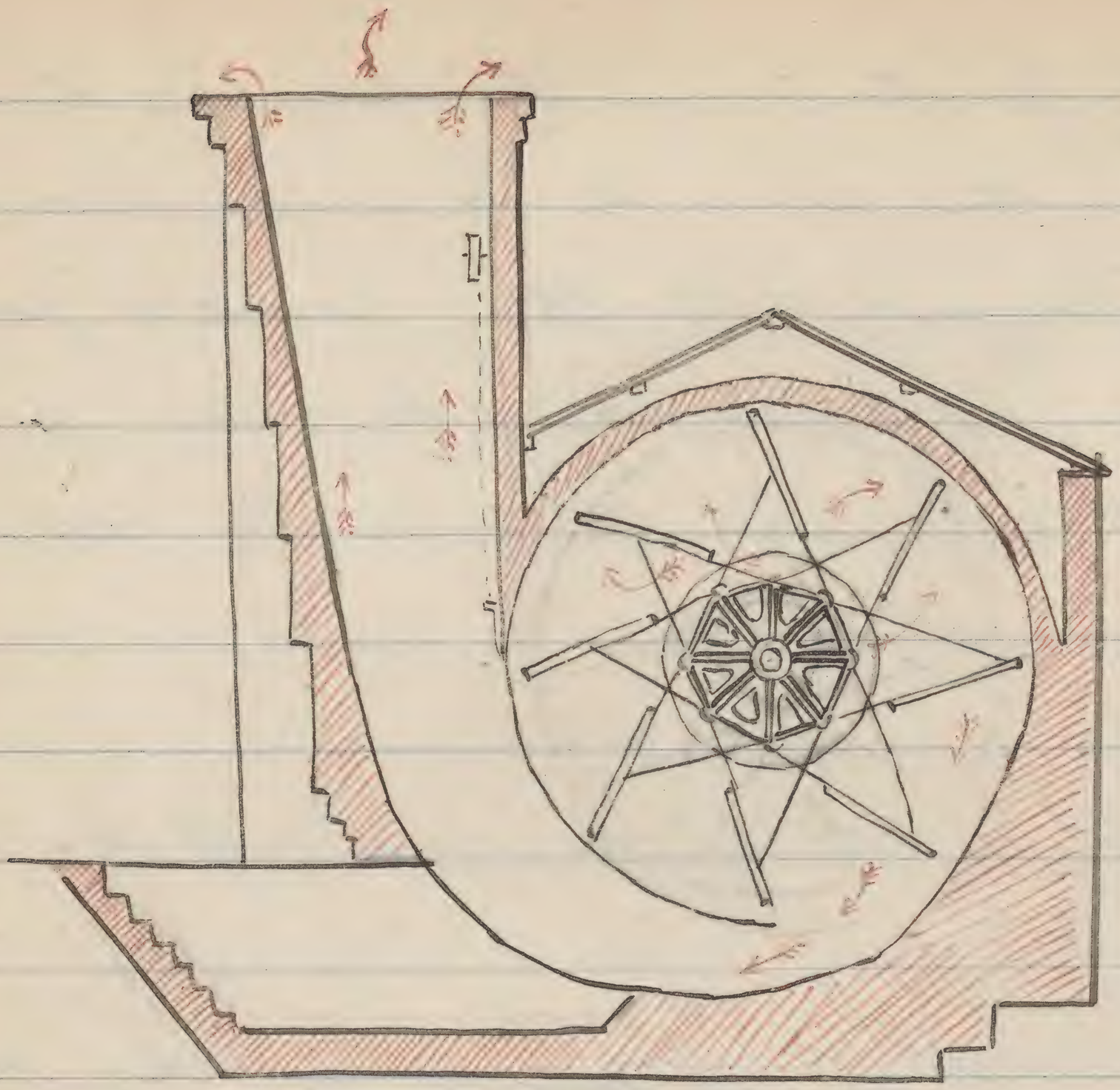
a conical piece pointing in the direction of the level there where the air is to be conducted - a jet of water then playing into this conical piece (collected in an overflow vessel beyond) will carry the air through with it and the air will pass forward in the level.

Machines in which ventilation is effected by the rotation of a fan.

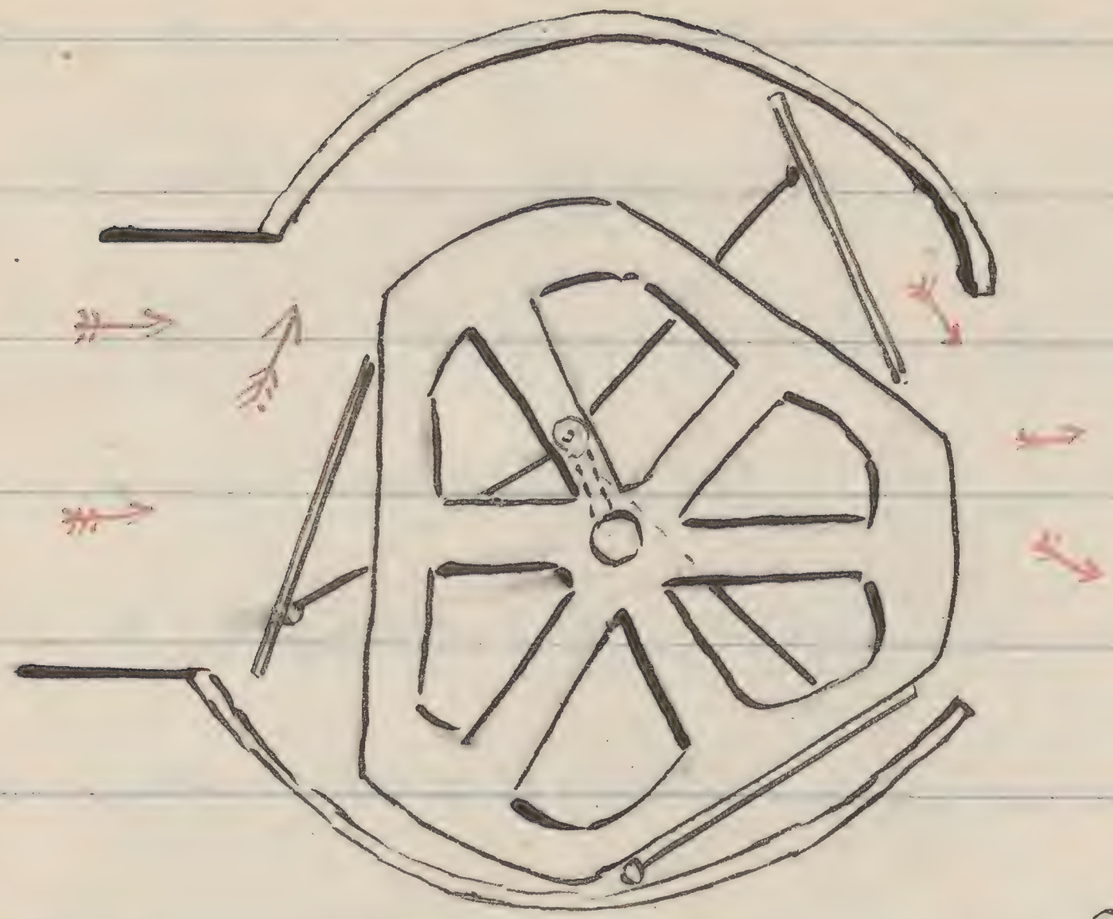
very old process, yet employed on a very small scale till quite recently. Mr Brunton proposed to place the fan over the shaft, and the air to be admitted at the centre & thrown out at the exterior by a series of curved vanes. Nasmyth erected several kinds of fans, with fan placed vertically and with simple radial vanes - not by any means a success.

At the Exhibition of 1862. M. Guibal, a Belgian engr exhibited drawings of a fan to be 28ft diam. and 12ft across, to make 60 revolutions per minute, and that 74 p.c of useful work could be obtained. There are a great number of them now in use.

Guibal's Fan.



A circular case of wood or brickwork encloses the fan, communicating on one side with a trumpet shaped small shaft for the exit of the air the air from the mine being admitted at the centre of the fan. The paddles are interlaced in such a manner as to give a strong frame, and in front of the exit aperture is a curved apron or door which can be moved up or down, so as to regulate the size of the aperture. Some of these in the N. are 36ft. diam. 12ft wide. & some 46ft diam 14ft wide. The moveable apron is adjusted till the position of greatest efficiency is found. The trumpet shaped exit shaft is advantageous to counterbalance the evil effects of the great velocity given to the air, enabling it to expand, and therefore to issue more readily. It is usually preferred to have 2 engines fitted to these machines, so that should anything go wrong with one the danger of stopping the ventilation will not be incurred

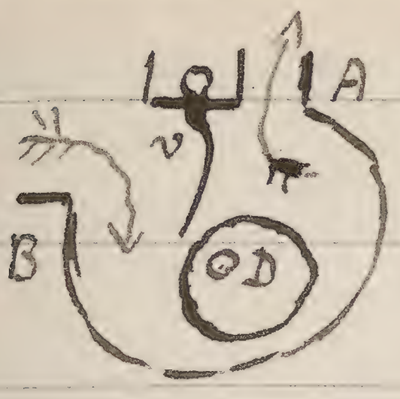


Lemielle's ventilator.

Other fans in Belgium and by Mr. Waddell in England, very simple, a vertical fan revolving in front of a brick wall and air being admitted to the centre of the fan through an opening of the wall opposite to the centre. The fan was of sheet iron, 80 revolutions per minute. The difficulty at first was the leakage between the fan and the wall, this was got over by making the wall in that part of cement carefully smoothed so that the fan could run very close to the surface. Machines on the principle of varing capacity - Lamielle's On this you have an outer drum or case placed eccentrically, the valves are attached to this and also to rods which are attached to the point in the centre of a large outer drum. This acts as in the feathering paddle wheel the vanes or valves being opened out in one pt. of the revolution and drawn close to the sides of the drum in another.

Fabry's used in N. France and Belgium. the machine has 2 wheels, each with 3 arms, & each of these arms again having a cross piece, each having along its extremity a curvilinear piece of iron which come into close approximation during the revolution and so prevent leakage, at the same time other vanes are sweeping out the air rising from the pits

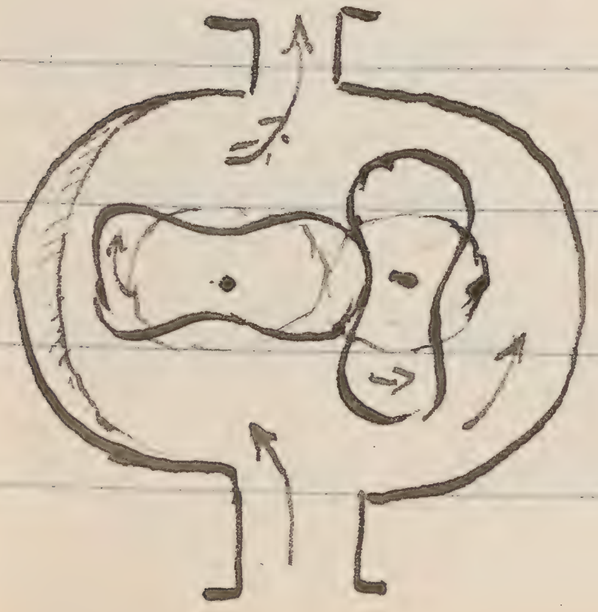
Cooke's ventilator



consists of an outer envelope or case (A B) and an iron revolving barrel (D) placed eccentrically — the diameter of this barrel in the larger machines being 8 ft and the radius of the circular envelope 6 ft. A peculiarly constructed flap valve (V) is connected separately and worked by a separate arrangement the space between V and B communicates with the shaft, between A & V with the outer air. As the barrel revolves in the direction of the arrows it will sweep out the air before it.

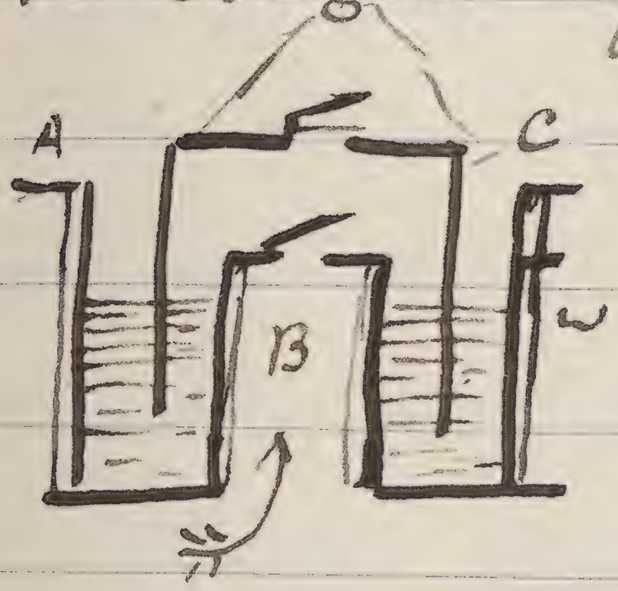
Root's ventilator

used in California and in metallurgical works in the U.S. and in Cumberland.



Inside an outer case two peculiarly curved arms revolve against one another, in such a manner as to sweep out the air before them in the direction of the arrows.

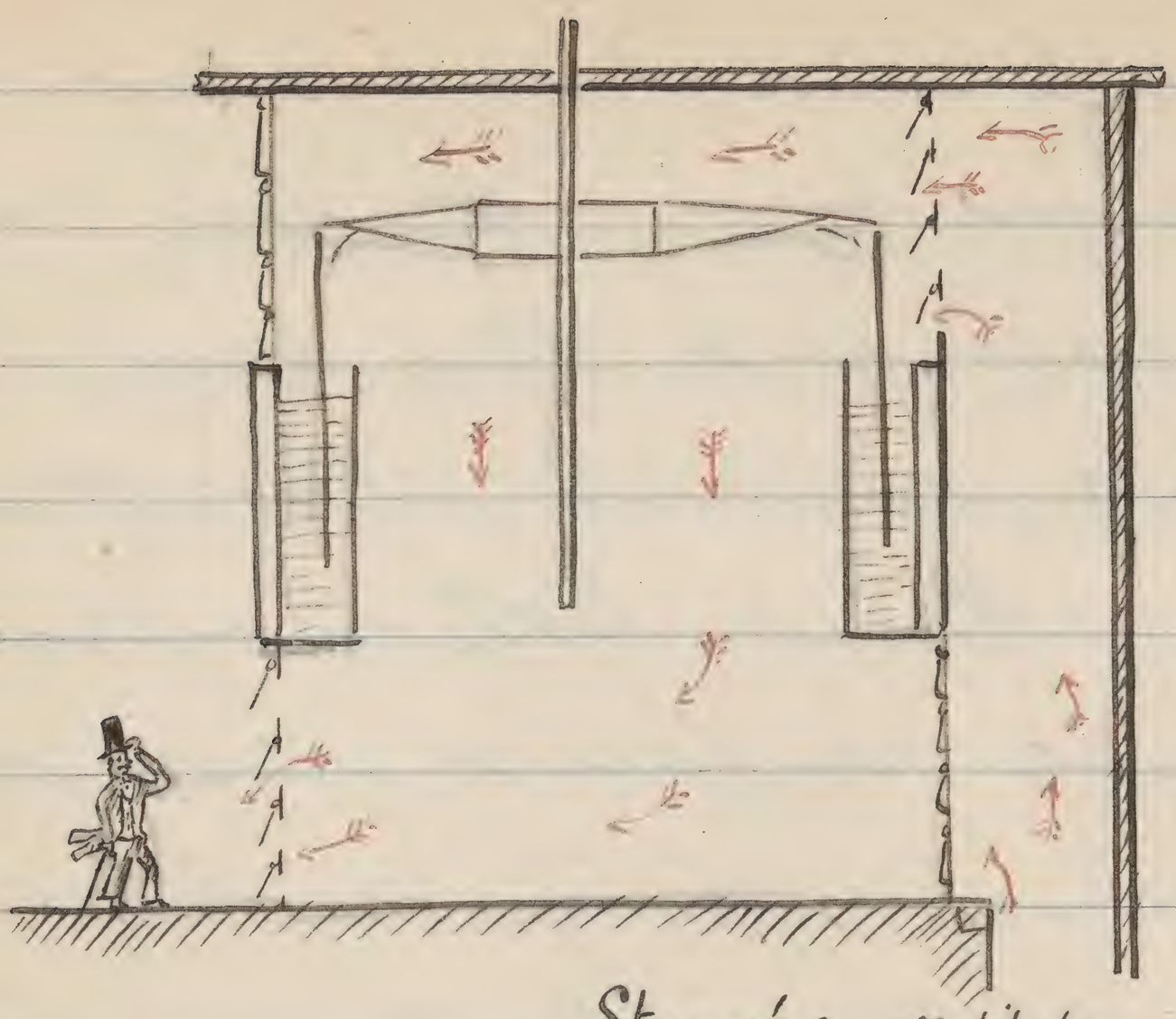
Varieties of Air pumps which have been used
The 'duck' machine in the W. County - in Germany
the Hartz mine pump. Thrugh this received a
premium from the Society of Arts it had been
used in Germany for 150 yrs.
It consists of an outer tube or box, within



which is a pipe made of wood
or sheet iron (B) opening above
by a valve working upwards
and communicating freely below
with the pipe bring back the return foul air.
Below the outer and inner tubes moves a third tube
C, up and down, open below, but with a valve
opening above - the lower part of this moves
in water, so as to prevent the escape of the
air except through the valves. When the tube C
moves up, the air to be exhausted passes
through the valve of B and is driven out
through the valve of C which is again depressed
The frame C is attached by a frame of iron

or chain to a lever by which it is worked, and it may be so arranged that the lever shall have a pump at each end thus being balanced. When this works on a moderate scale, from 1½ to 2½ drain, it is a very efficient little machine. It may be placed at the surface or at the mouth of a level.

Put up on a large scale in Belgium - with cylinders 8 - 10 ft diam - like a working pump barrel, the valves were made in various ways, and were fitted with counterpoise weights, having fulcra on the piston rods, by which means the valves opened more easily and with less pressure. At the base of the cylinder in which the piston worked is a clack valve of a similar character. The machine worked like the last one, but instead of using water the friction of the piston against the sides of the cylinder came into play.

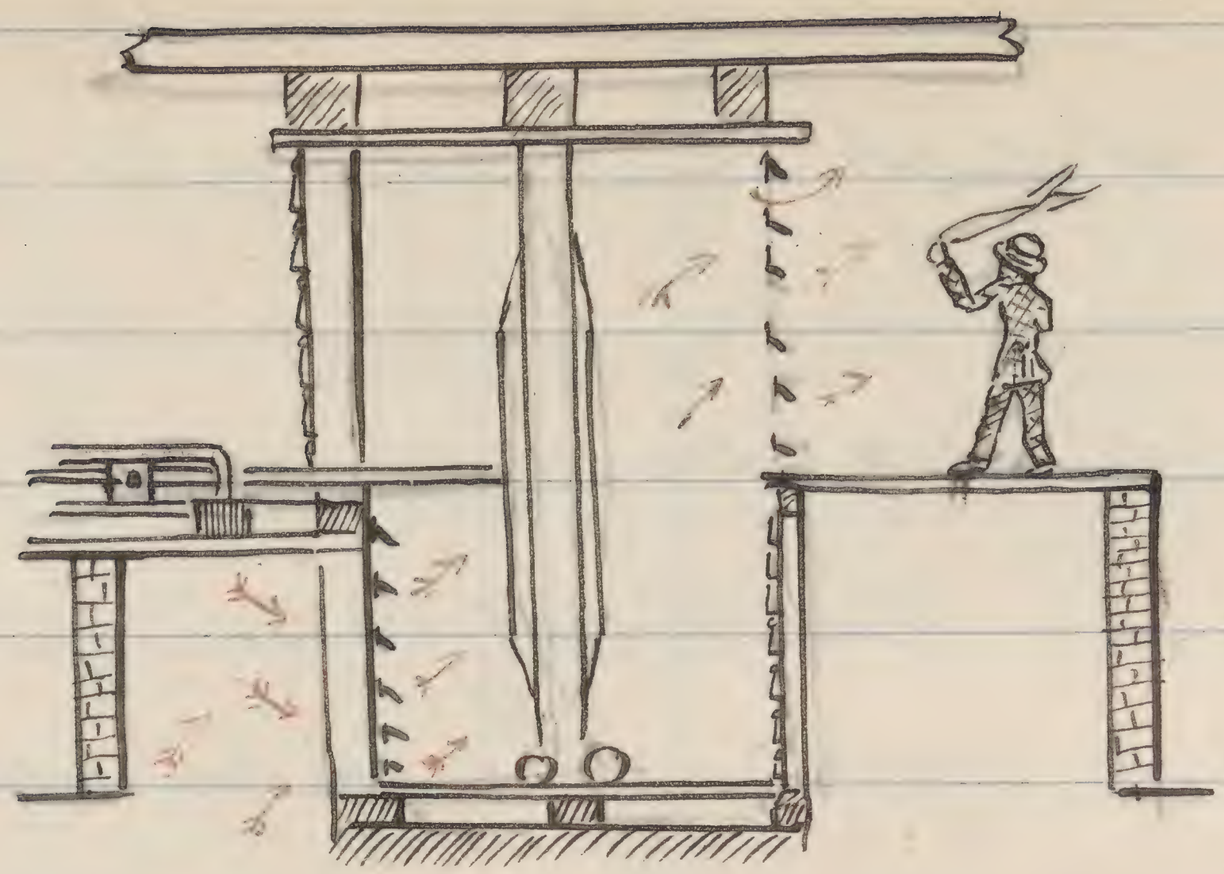


Struvé's ventilator (scale 3/4 in. to 10 ft about)

Struvé's improvements.

A sort of sheet iron belt, like a gasometer, worked within an annular interior space constructed of brickwork, which contained water to secure a water tight joint. The air shaft ran up one side of the belt and a system of valves were arranged on both sides those on the side of air shaft opening inwards, those on the other outwards. The arrangement was such that both in the upward and downward movement of the belt the foul air was admitted into one part of the apparatus, while that previously taken in was driven out from another part. These machines were at first 14 ft. diam. afterwards 24 ft. and one engine worked two suck pumps. Objections are the expense consequent upon the variety of construction needed, and the trouble given by the flap valves. The machine has not spread from Wales.

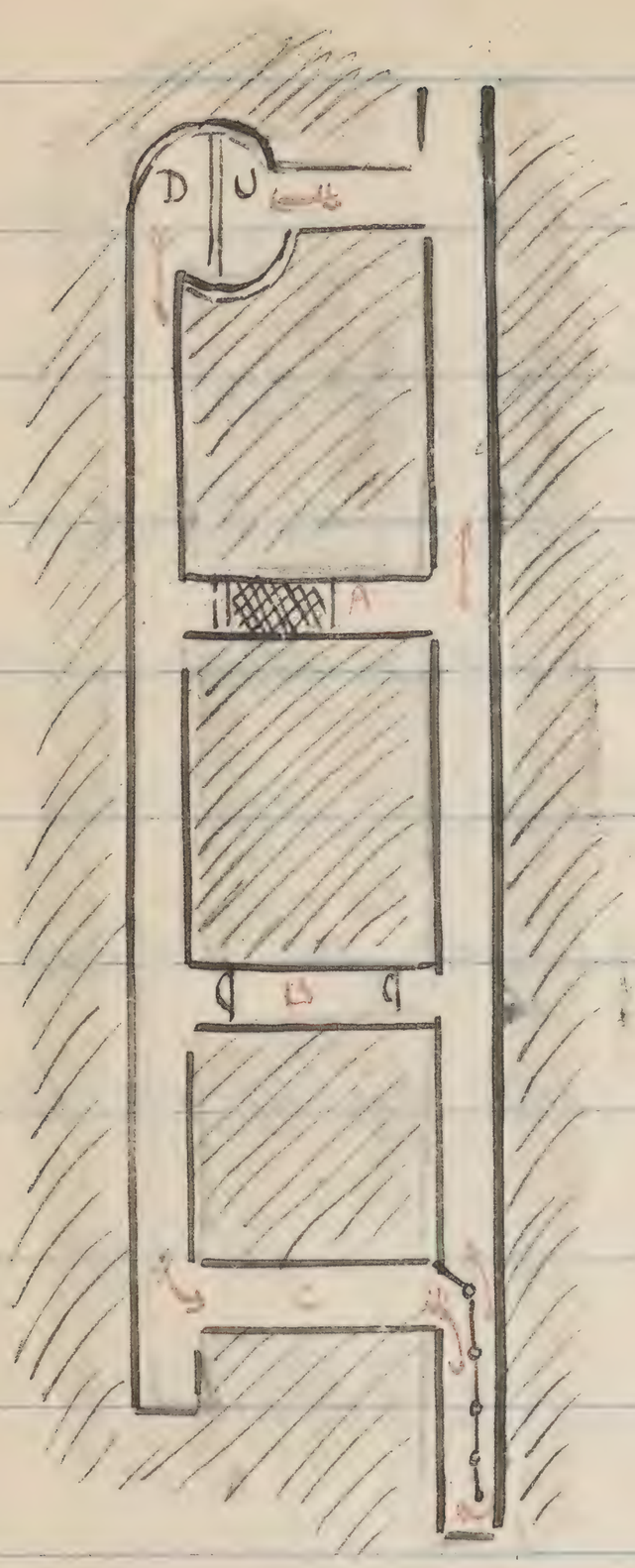
Horizontal Cylinders - 1828 M. Bisco. a Belgian. Erected a small machine at Charleroi



Nixon's ventilator - Aberdare.

On larger scale in 1856 by M. Mahaux.

Mr Nixon at the Navigation pit, near Aberdare, erected similar apparatus on a larger scale, & with double action. The chamber in which the piston worked was 30 ft. x 22 ft. the area of the piston 660 sq. ft. the length of the stroke comparatively small. 7 ft. The piston (13 tons) was of brick work, supported and moved on 2 pairs of wheels, running on rails. A series of flap valves (672 in all) each 16 in x 24 in, were connected with the apparatus and when open reduced the chamber to a mere framework. Two lower sets of valves opening inwards communicated with the off take, bringing the return air from the shafts, two upper series opening outwards gave exit to the expelled air. The engine which worked this air piston by means of a crank had a cylinder 36 in. diam. & stroke 6 ft. using high pressure steam - 9 strokes per minute. giving a theoretical volume of 166,320 cub ft. which with 12 strokes could be increased to 200,000 cub ft. Objection is expense, not so effective as the furnace, not used elsewhere.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The manner in which the air is to be distributed to the various parts of the mine.
Great improvement in ventilation during last 30 yrs by attending to this. The great deficiency in former times of arrangements for the distribution of air is proved by the use of shafts - Kilkenny coalfield, some parts of Wales, & Forest of Dean riddled with small shafts.
In the present day in stratified deposits, take the case where two parallel roadways are being driven at a short distance from each other. Ventilation is effected thus, when the men have passed along some distance and the air slackens they look through or thirl the air circulates again. When they have advanced further they must open a fresh thirl and stop up the former by a "Stopping" As long as there is a current it may be made to circulate thus. If there are side workings or bords opened out from these main roadways the air will be made to pass along the side level by placing a brattice across the main road -

with a door in it for passage when required and the lattice will be carried up the middle of the side level to the end and also into any branches thus forcing the air to pass along those parts before it returns to the main roadway again. Similarly thirls will be driven through between different boards and by means of stoppings, doors, and latticed the air will be made to circulate through all these parts and at length be allowed to escape into the main level. With regard to the stoppings the thirls that do not require to be used as thoroughfares will be filled up when they are supplanted and usually the stopping will be put in of brickwork not necessarily of any great thickness where explosions are not to be expected and then rubbish will be stowed in at the back to strengthen the brickwork. In some cases, where extra strength is required the brickwork is put in of an arched form, sometimes double, the two arches having their convex or concave sides opposite

The doors.

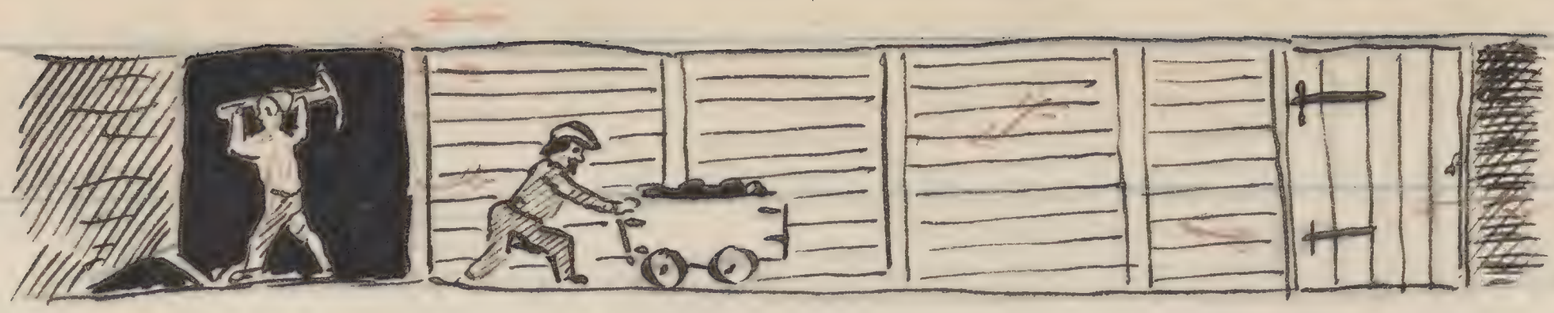
The main doors, which are placed in the levels, which communicate, nevertheless, directly between the down cast and upcast shafts, on the integrity of which it depends whether the air shall pass through the mine or take this direct course and leave the whole of the remainder of the mine dead. Generally 2 of these are placed (sometimes 3) - at a distance apart to allow of a train of wagons standing between so that one door may be closed before the other is opened. They must be made very strong and carefully, especially in fiery collieries, for not only is it necessary to prevent leakage but to withstand as much as possible the force of an explosion, for if these doors be blown down the ventilating current will take the direct course to the upcast. Mr Buddle proposed a remedy, that a spring door to hang vertically should be placed in this part and kept laid against the roof, propped up by means of a board. An explosion blowing down the doors would blow down this board & the swing door fall in its place.

In the St Etienne collieries sheet iron swing doors are used, counterpoised so as to be brought down with considerable facility

Dam-doors, also suggested by Buddle, In a stone drift (e.g.) between two districts of work stout jambs may be fixed and doors provided and always set ready to be put in place. If a fire occurs, a door can be put in and luted with clay thus preventing access of O to the fire.

Sham-doors - are put in in places to stop the air to a certain extent and capable of being shd backwards and forwards - hence sometimes called "regulators."

Another class of doors are those by which the officials have access to the return air course, without the necessity of following the intake air in all its windings. (man-doors)



On many of these doors the safety of the colliery depends and it is important to be able to rely on their acting properly. The question how this is to be secured whether by machinery or by trusting to human beings is much disputed. The trappers or boys who look after the doors may go off to play or go to sleep, but this is not so bad as trusting to machinery.

Although devices have been proposed by which the approaching wagon shall open the doors, machinery has not found favour.

the Brattices employed for carrying the air further than it would otherwise range. A row of pieces of timber are placed like props and then boards of ½ in. deal nailed to them, making a sort of wall. This need not be absolutely air tight.

Within the last 15 yrs a strong canvas has been much used, introduced by Mr Darcy Lever. Very simple. & Rapidity is an important advantage in cases of re-establishing the ventilation after an explosion

Air crossing.

Objections are the smell of tar and it is very inflammable. A kind of tarpaulin canvas has been used for doors.

In the older methods of working the no of doors was very large, improved methods have reduced the no

The crossing of air currents where we have two running in directions which cross one another at a certain point. In midlands a mere trough or air box is used for one of the currents but this is very objectionable. So in large collieries one of these roads is made to rise up and pass over the other. The separation between the two will be merely a covering of stout boards, rendered air tight with clay. Risk of an explosion blowing out this partition.

Strong arches of brickwork have been proposed, but these are vulnerable if the explosion catches the inner side. At Wigan boiler plate has been put in with great advantage, in other cases the return course has been left up to some distance in the upper measures at the crossings, so as to leave several yds. between the 2 courses.

During the last century there were, in the N, usually 2 shafts and a furnace, and the intake current was led round the whole of the outer pt. of the workings while the inner pt. of the workings remained unventilated.
Objections are - if the colliery be extensive, there will be a vast mass of dead ground in the centre, in which CO_2 and CH_4 may accumulate. And again the current gets so foul as not to be fit to supply any more men, & yet it has to traverse the whole round. In 1760 Spedding proposed to make the air pass backwards & forwards through the whole workings before it was returned to the upcast, 'coursing the air in twos and threes.
Here again the current had to travel 10-50 miles.
When the workings were divided into panels, it was suggested to split the air current.
Where the shafts were of ordinary dimensions they were capable of conveying a volume of air which was out of all proportion to that which could pass along one leg.

read
(Small book by Mr Atkinson. H.M. Inspector of Mines)

'Treatise on the gases met with in coal mines' - Longmans. 7/.

Laws relating to gases necessary to bear in mind
Mariotte or Boyle's law. that the volume of a
given weight of air is inversely proportional to the
pressure on it, so long as the temp. remains unaltered.
in other words the density varies as the pressure on it.
Gay Lussac's law. if the pressure remains constant
the increase of volume imparted to air by heat
is uniform and equal for each degree of heat.

friction of the air on the sides of the passages.
The friction varies directly as the length of the gallery
and as the square root of the velocity of the
current.
Again the friction increases inversely as the sectional
area of the gallery.

In galleries of equal section and which differ only
in their lengths, the volumes of the currents which
will be obtained will be inversely as the sq. roots
of the lengths.

A satisfactory method of ventilation is to divide the mine into panels and take off a separate & special branch of the intake to each panel.

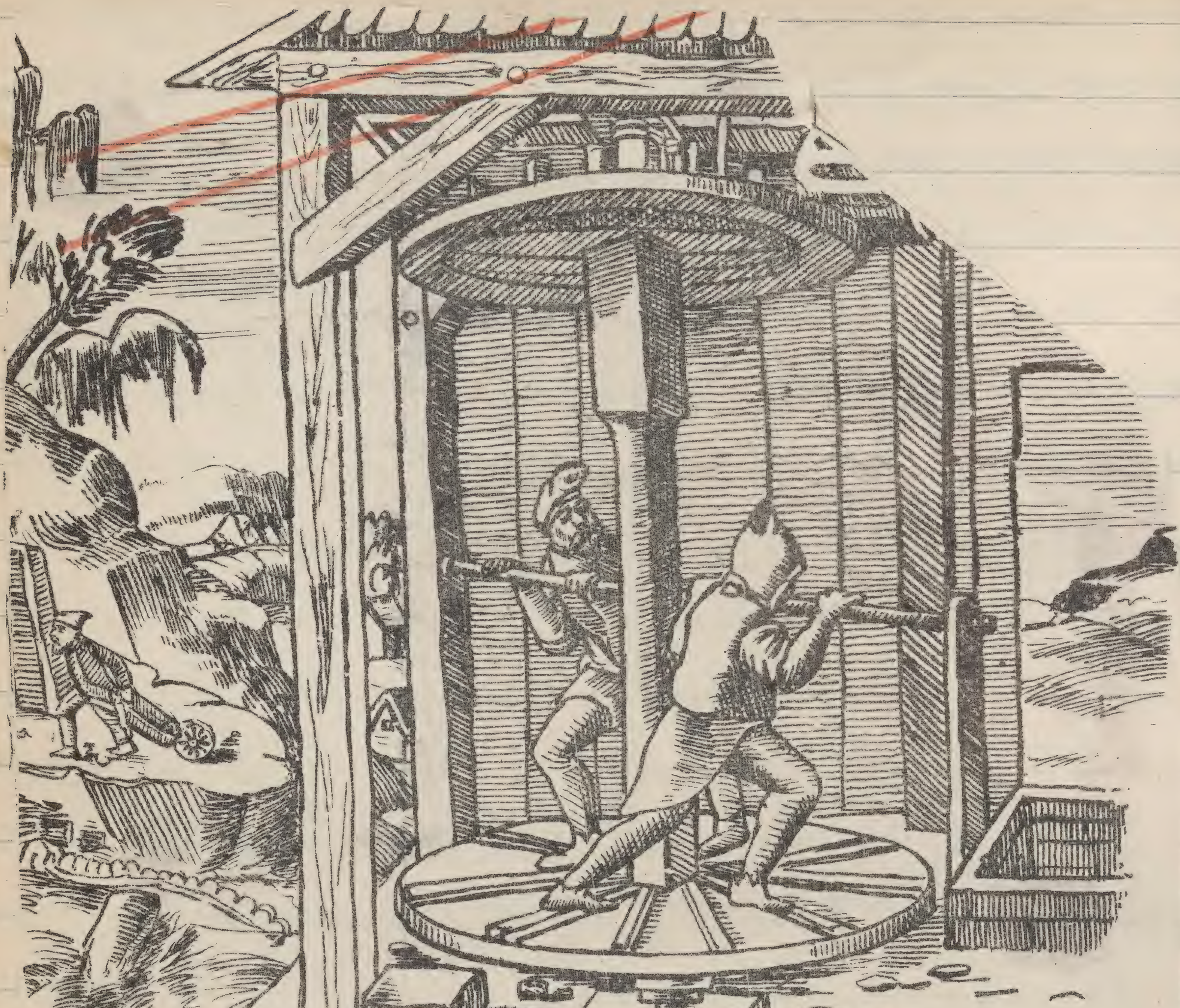
However the ventilation may be arranged, one of the most serious points is that of the breaking down of crossings or forcing a clearing open of doors.
It is always the case that after an explosion $\frac{2}{3}$ of the men have been killed by suffocation
It is desirable to leave a wide margin between the pillar workings and the opening out of the roads in advance - 3-5 pillars should intervene - & the air from the face of work should be made to pass ~~through~~ between these successive sets so as to introduce a long course between the pillar workings by lamps and the road probably by naked lights. This is necessary because any heavy fall in the pillar district tends to force back the air and as great volumes of gas are liable to accompany these falls, it would be a most disastrous occurrence if this were forced back on to naked lights.

Where the air is split there will be a tendency for the greater volume ~~of the~~ to pass along the road which offers the shortest course. So that unless the two courses be nicely balanced, regulators must be put in.
It is desirable to have as great a distance as possible between the two shafts, that whatever may occur there will be passages in which the current is kept up and to which there will be a chance for the survivors to escape.

An experienced collier will be able to tell you from the flame of his candle the state of the ventilation — A common plan is of ascertaining how fast a small cloud of smoke from a pipe or a flash of powder travels along, noting by aid of a stop watch or sandglass. Thus if the level be m feet x n feet and the velocity be V feet per minute. m x n x V = no of cub ft passing through per minute.
Several Anemometers have been devised for this purpose — About 30 yrs ago the first was proposed

by Mr Biram - now generally used. It consists of a light wheel, with a no. of vanes made of some light material (oiled silk) set at an angle, so that when the face of the wheel is placed in the current the wheel revolves. It is so arranged that for every 2/t of air passing through the wheel makes 1 revolution and an arrangement of toothed wheels registers the no. of revolutions made. They are of various styles — some made for the pocket. By placing them in the centre of the level you get the true amount as the air moves faster at the sides. A simple one was proposed by Prof J A Phillips, improved by Mr Dickenson, where the force of the current pushed out an arm with a vane attached, the amt. of deflection being read off on a quadrant. Casartelli's anemometer like Biram's but smaller.

The water gauge - application much misunderstood. If one of the arms be placed in a door or stopping connected with the return air the difference of level of the liquid in the 2 arms will give the difference of pressure of the air in the two levels. Used alone it tells very little but as an auxiliary of great service. If (e.g.) it has been noted as standing at a certain height & suddenly falls, indicates by some cause or other the current is checked.



"CRUSHING" (OLD STYLE) 1558.

57. Ore dressing operations. (Ger. aufbereitung)
Fr. 'mechanical preparation' In England dressing or washing
As only a small proportion of the minerals raised to the
surface are in a proper state for ~~transferring~~ passing into
commercial hands, the miner has to transform the
crude products which are brought to surface into a state
in which they can conveniently be sold.
The amount of dressing required varies much according to
circumstances. 1. the consideration of the intrinsic value
of the materials. For instance it would be no use
to attempt to work iron ores which required much
dressing, no matter how good the quality.
With coal, if a seam of moderate thickness contain a
parting of more than a few inches thick, the getting
asunder of this from the coal may materially interfere
so much with the value of the seam as to render it
a question whether it is worth working
Copper ore is dressed up to 5 or 6 per cent. This is
the percentage the smelter requires so it is unadvisable
to expend money to bring it up to a higher page

Tin has to be dressed up to 75 p.c. In some of the best Tin mines in Cornwall the tin stuff as it comes to the surface contains 2 p.c. in some cases 14 lbs to 1 ton of crude material is sufficient to pay.

Lead must be dressed up to 70 p.c. at least.

If a moderate proportion of Ag be present it may pay if there is 1 ton of metal to 24 or 25 tons of stuff

In the case of Au & Ag very much smaller percentages may be worked, 1 oz to the ton of gold will pay well. St Juan d'El Rey mine was worked for some time with ½ oz to the ton.

In Eastern Europe, Schemnitz, Austrian Alps etc where water power is favourable, 2 oz of Au to 50 tons is dressed

The most wonderful case Prof W. Smyth saw was at Zell in the Tyrol where they dressed some slaty material with 1 oz to 50 tons.

The dressing of non metallic substances — Coal — Formerly the small and the large were sent

away together but it is now found necessary to screen them

The separation is effected by having a screen placed at an inclination of 18 in. to the yd. or about 26°. And the screen consists of a framework with iron bars parallel to one another. The space between the bars varies, sometimes it is 3/8 in. - 1 1/4. This however depends on local circumstances the small will be useful for coking in others it will be valueless. The bars have usually parallel sides, sometimes they are conical so that pieces of coal may not be so readily fixed. In Scotland the screening is sometimes done with a shovel, made like a gridiron, while the coal is being loaded. The wagons are run along the rails to the screen and then, either by a door to the wagon or by a tipping arrangement, the coal is thrown on to the screen

In nearly every case the screens are rectangular. 10-16 ft long - but in Lancashire an inclined cylindrical rotating screen has been introduced but few of them are now left.

3 4
5
5
18

The preparation of Kaolin.

a product of the decomposition of Granite and for commerce has to be separated from the Quartz and mica. If this occurs on a hill side slopes will be cut in the hill and a stream of water will be made to flow over the face of the slope. The water, aided by a little work with a broad pick, breaks down the clay and carries forward the Kaolin and mica, but very soon drops the quartz or gravel. This gravel is partly thrown away and partly used floor of the evaporating pans. The great point is to do as much work as possible with water and save manual labour. The water then passes into a no. of small pits, where it is brought almost to stagnation and as it passes along slowly backwards and forwards, it deposits the mica, it then passes into a no. of evaporating pans where it is left slowly to evaporate, leaving behind a deposit of pure white Kaolin, free from Silica and Mica. When the sediment in these pits is 8 or 10 in. it is dug out before it hardens. For the purpose of expelling a good deal of the water it is placed under sheds in the dry season & is dried by heated pipes. The Selling price is £1 to £2.2 per ton.

(Classified dressing floor establishments
see Engineering. Feb. 1876)

Coming next to metallic minerals — It is very important that there should be in the mine itself some arrangement or division. Generally the only division is that between ore and attle. Useful as far as it goes, for if stone is sent to the surface it costs money And is useful in the mine for filling up.

In some cases in the N. of England instead of having a small dressing floor connected wit each pit, the ore from the different pits is accumulated at one central establishment and there dressed.

No system of washing has been more successful than Mr Rittingers drum — which is conical and made to revolve on a horizontal axis so that the ore which is placed in at one end travels down to the other. In so doing it is sorted all but the larger falling through the bars into the outer case that which falls through is taken up by a revolving arrangement and delivered on to an

inclined plane - From this plane the ore slides down into a second drum in which the fines falls through in one portion, a little coarser another, while a still coarser portion does not pass through at all. Thus the machine sorts the whole into 4 distinct portions according to their fineness

The various classes into which it may be desirable to divide the material. 1. Prill (stuf-erz) the best division in N. Emg ore.

2. Best dradge ore (Aufschlag erz) which is mixed with a quantity of stone and will require to go through some process of comminution, moderately rich

3. Second class of dradge ore (Wabz-erz) which is only suitable to be dressed by some concentrating apparatus 4. Stamped stuff (Pocherz) of which in a large mine with varied products, it will be advisable to have two different kinds viz 1st. Halvans (Berg-erz) 6 Deeds or attle (berg) the materias to be thrown away.

Processes for comminuting the ore.

very often breaking by hand is sufficient, but when the quantities are large the crusher must be used - taking care not to mix with inferior ores. Where the ore & matrix are not very hard a good deal is done by hand. Spalling hammers weighing 6-8 lb. even to 18 lb.

Obviously it will be a great advantage to separate the materials as much as possible. Cobbing hammer. (short handled, the head being a comparatively long bar of iron, curved, and with the convex side towards the hand, & with rect. ends)

The people working them are arranged at long tables with 'knocking stones'.

The further breaking up of the classes 1 & 2 will be done with a 'bucking iron.'

Over & over again it has been proposed to use the Tilt hammer, lifted by arms from a wheel & aided in its descent by a strong spring but throws about the stuff in all directions and is not used now.

Nasmyth's and other steam hammers proved
"Blakes stone breaker" now largely used.
It is made excessively strong, a strong bed of
cast iron slightly inclined (angle adjustible)
supported against a strong pillar: a moveable
piece of iron which moves through a short
distance, crushes the pieces of stone against the fe
bed & then allows them to fall between. The pieces
thrown in ought be from 6-10 in diam. 120-160
blows per min. The material falls through
partly as powder or as small fragments, size to
a great extent regulated by the opening you give
between the lower ends of the plate. Sometimes the
machine cannot be used advantageously giving
too much powder. An arrangement should
be attached by means of which a stream of wate
should separate the material which passes
through.

The Edge rolls.

a circular bed plate with 2 millstones connected by a horizontal axis set to run round the bed. The rubbing edge is generally a band of iron so is the bed. This sort of grinder can only deal with small quantities & some of the material is ground down to an impalpable powder. The Mexican arrastra, in this there are two long cross axles with a heavy block of stone hung at each end, these being the rubbing agents.

Berdan's machine — successful for a time.

A large cast iron basin somewhat inclined was made to revolve and the rubbing was done by two loose balls in it, of 24 cwt and the other of 9 cwt.

Similar machine introduced by Britton, (Dolgelly) a sort of pestle. is worked round in the basin by a crank movement from a water wheel.

The crusher.

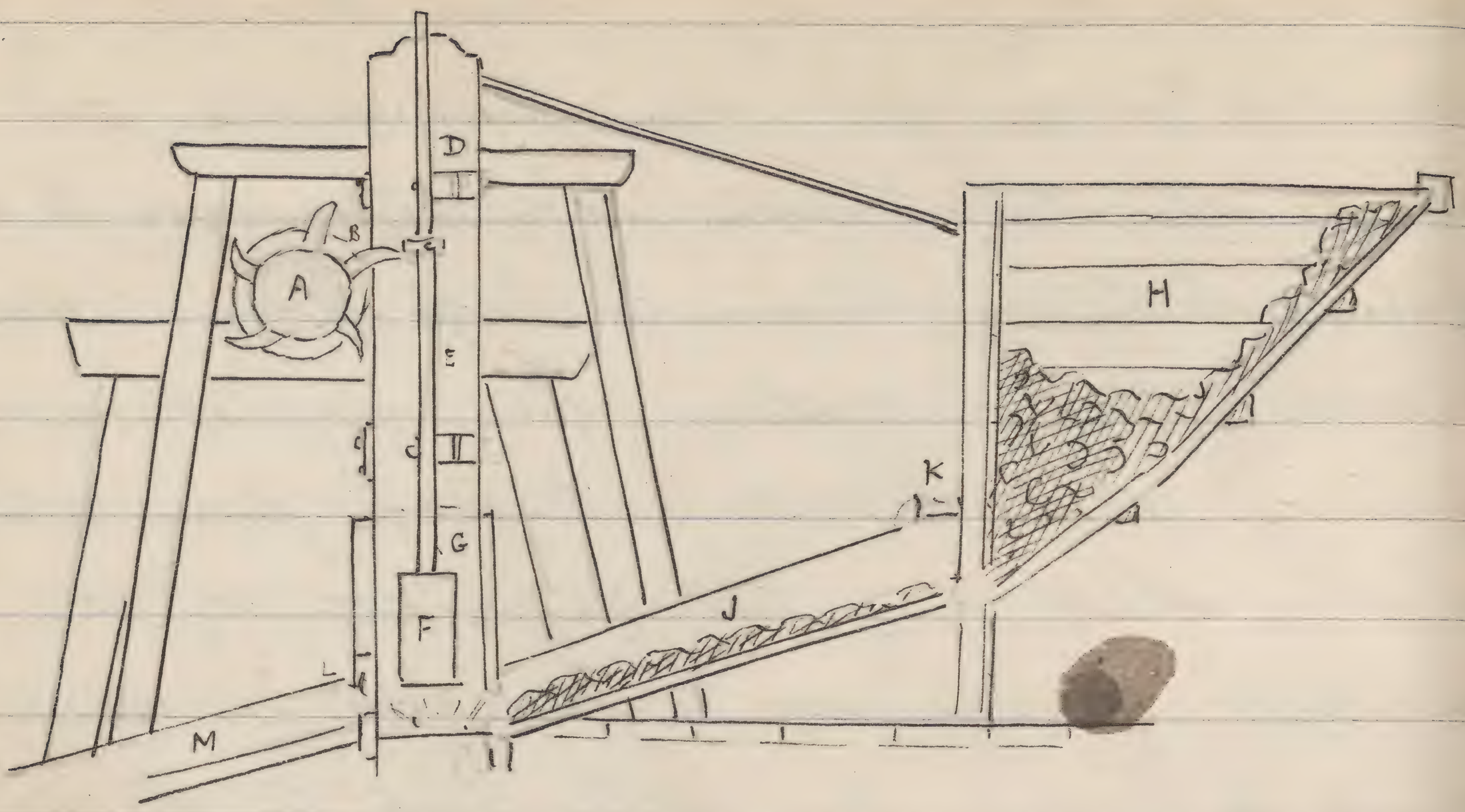
consists essentially of a pair of rollers, which are mounted on a strong frame and rub against each other, The main points to notice are -1. there are two cheek pieces or frames of cast iron 5 in. to 6 in. high resting on a strong beam, the whole length of the frame being 7 ft. near the ends are strong uprights about 1 ft high. The rolls are fitted into the frame by the intervention of 2 plummer blocks, the blocks on one side being permanently fixed close to the upright, those on the other being moveable to allow of adjustment of the distance between the rolls. The rolls are made to revolve towards one another by a suitable axis or shaft usually direct from the water wheel if the wheel is on a small scale or by means of gearing if a different velocity from that of the wheel is required A lever 8 ft long with a weight at its end

is centered to an arm from the upright adjoining the movemable block and one arm is connected with this block.
In case of a piece of iron ~~or steel~~ getting in between the rolls, it will merely force the rolls apart by lifting the weight at the end of this lever.
It has been found advis-able to shorten these rolls and to increase their diam. being commonly from 2 ft to 30 in. diam. down to 3 ft in. the breadth not more than 10 or 12 in. At Dowlais Great Consols rolls of two different breadths 34 in rolls, one 22 in, the other 24 in. broad.
The rolls consist of 3 pts, a square shaft an outer solid piece of cast iron called the core, and outside the shell. The latter is usually of cast iron sometimes chilled and after it has undergone a certain amount of wear it is removed from the core and another put on.
In Germany they employ stout springs instead of the lever

What is the velocity which should be given to the rolls to get the best work out of them and should water be allowed to pour down between them to help them cool and assist their action? In the case of many of the Pb ores derived from strata of clay slate a great quantity of the vein stuff is apt to make up a very adhesive clay and to clog the rolls, so that water cannot very well be used. With Quartz material it is a very good addition. The speed must be varied according to the character of the mineral. 30-80 ft per min. of the circumference of the rolls. 5-15 tons of ore may be crushed per hr. The material is sometimes next allowed to pass into an inclined sieve.

The may be a strong pair of rolls with teeth from which the ore may pass to a pair with smooth surfaces.

(Unc. f.673)



elevation of a Cornish steam stamps.

A axle. B cams for lifting heads C tongue or projection on lifter DD guides
E the lifter F head of pestle G chest or coffer H hopper J pass grate
K launder discharging water into the coffer. L stamps grate
M. launder receiving the stuff after it has been flushed through the grates
N the bottom or bed of stamps.

LIX. Stamps.

As seen in its simplest form you have in the stamps a strong, usually a wooden, frame placed on an extremely firm foundation within which 3 or 4 of these stamp heads worked being raised from time to time by lifters. The stamp consists of a head of cast iron, rarely steel, weighing from 1 cwt to 1000 lbs and the lifter or shank of wood or iron from 9-12 ft long and strong enough to support the weight of the stamps head. The stamps are to be raised and allowed to fall through a height of 8 in to 1 ft. And the power which may consist of a water wheel, steam engine etc will give rotatory movement to a horizontal axis or barrel of cast iron on which is a series of cams, arranged in a certain order so as to raise the stamps by engaging with a tongue or projecting tappet; always taking care to have a full weight on the axis and yet not to overpower it

In the largest mines (Dolcoath etc) 100-150 stamps heads are in use

The lifter — formerly rect. logs of wood 4 in by 5 in and 9 ft - 12 ft long. now replaced by wrought iron. In section in this country rect. in colonial districts cylindrical.

The strong frame, consists of 2 uprights or a series in case of many stamps, connected by cross pieces which keep the lifter in place and should be able to be readily taken off for the repairing of the stamps. To lessen the wear sometimes a small loose piece of wood is put between the cross piece and lifter, but usually there are grooves in the cross pieces, lined with hard wood and triangular pieces of cast iron screwed to the lifter to move in the grooves. With many stamp heads they are divided by uprights into batteries, each with 3 or 5 heads and working into a separate box or "cofer" below. The engine may be placed at one end or in the centre.

The weight of the head must be greater for tough ore than for hard brittle quartzose rock.

At Schemnitz heads of 6-8 cwt used. The head is in the form of a parallelopiped of iron, with a more or less curved top, with a hole to receive the shank of the lifter which is then wedged in and 2 iron bars shrunk on. Sometimes the lifter is embedded in the casting of the head.
The stamp heads wear rapidly, losing much of its weight and mixing a large proportion of cast iron with the substance. To avoid this, chilled iron and steel have been suggested. In Californian mines they have a shoe fixed to the head which is replaced from time to time.

In dealing with a malleable material (gold) the prolonged action of the stamps beats it out into thin sheets, floated away by the stream
The same material must not be struck twice
The heads must be taken up in a definite order, but never the two adjoining ones at once.
Usually the head at one end then the other then the middle.

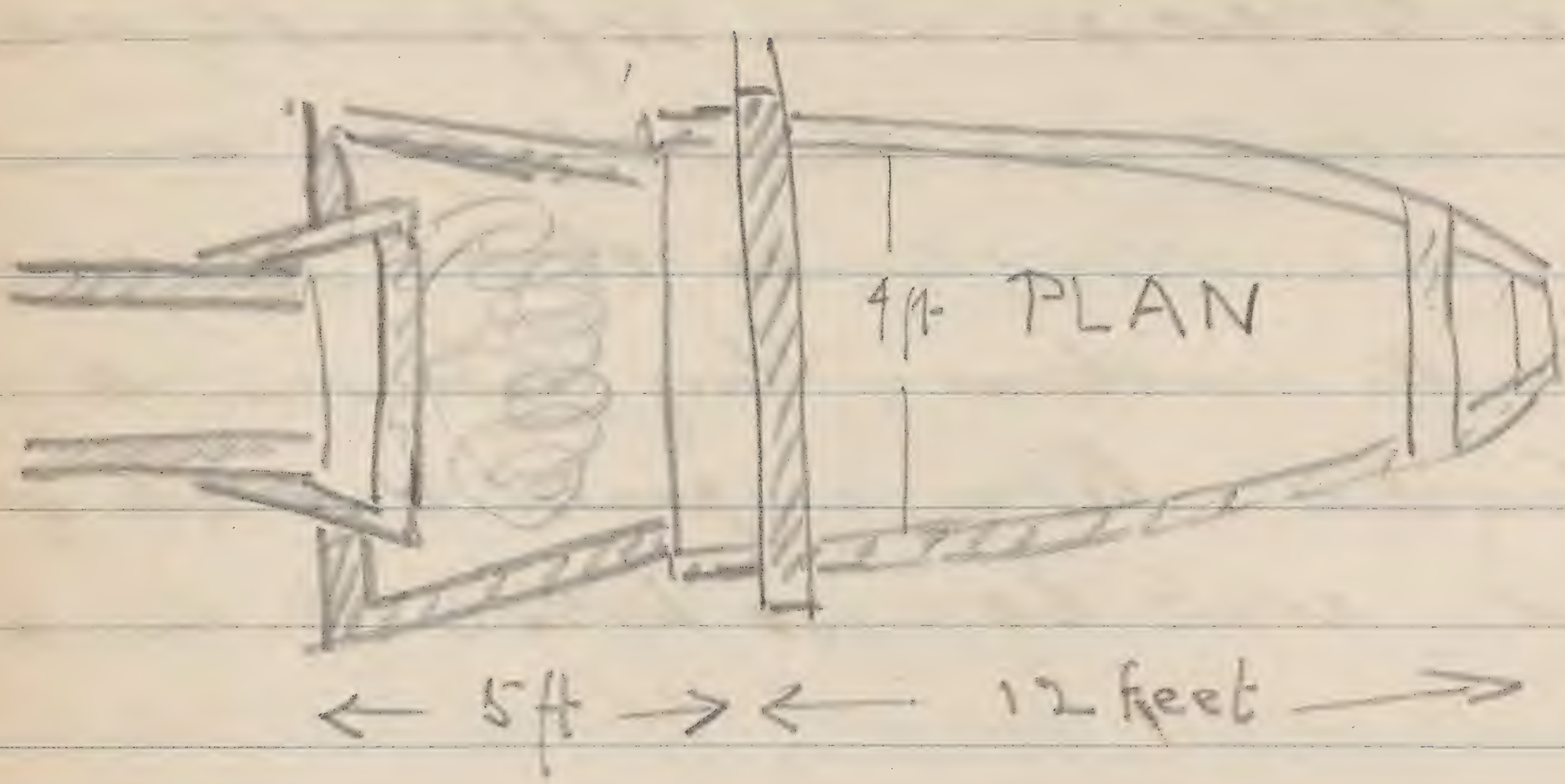
The outlet must not be too small to allow the materias to escape when sufficiently reduced A good dodge was to have the exit at a somewhat higher level than the bed so that the water had to lift the materias, thus ensuring its proper pulverization. Now a punched plate of iron is used with 60 - 300 holes to the in. is employed.

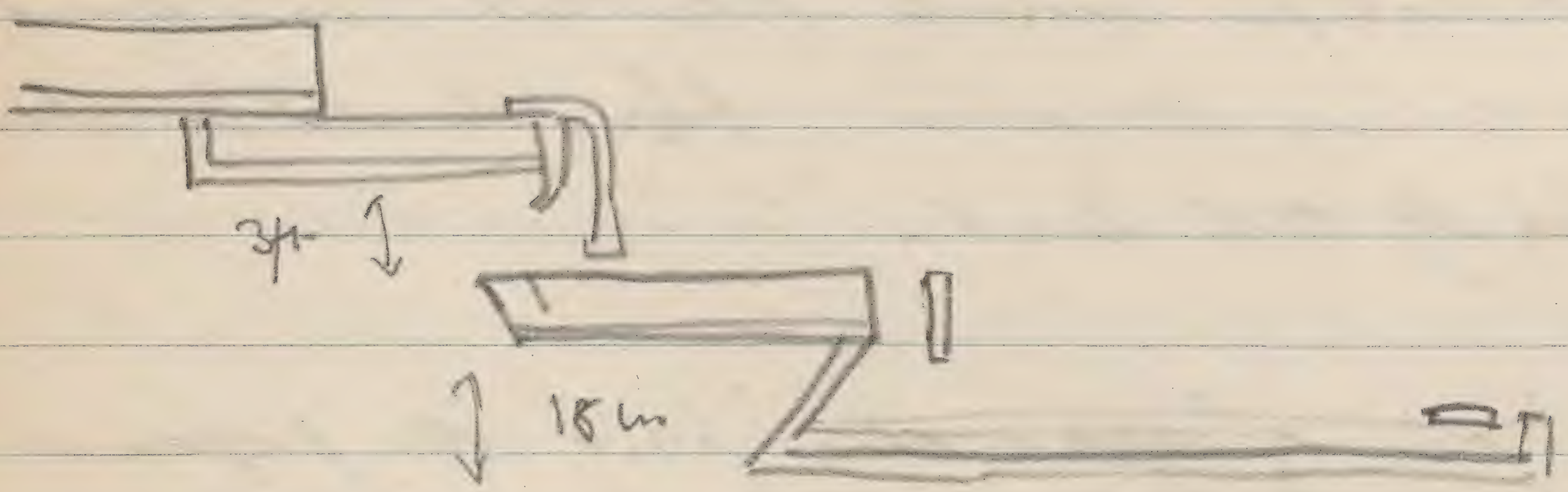
With 60 blows per minute for each head and with ordinary material 1 ton should be stamped in 24 hrs by each head.

Other varieties of apparatus have been proposed. Varieties of the Nasmyth steam hammer - The pneumatic stamp.

The nature of the bed on which the stamps ought to beat. In the American stamps a circular iron anvil with a square base is used - In this country a cast iron bed plate - In other cases the stamps beat their own bed -

Cornish Tin Streamers Dye.





LX. The methods of enriching & concentrating the divisions of the ore, which are of the nature of fine sand to slime, produced by the stamps and passed through suitable sieves

Simple arrangement in Cornwall for dressing the stream tin, where the matter is thrown on a plane surface, slightly inclined and a stream of water then allowed to flow over it. The larger portions are picked out and examined by the eye, the useless thrown away. Meanwhile the smaller sized materials will be carried on by the water and at the end of this plane will be directed by a hanging board into a box or 'tie' below, where it will run down a gentle slope and holes in the lower end of this box; as it tends to fill with sediment will be plugged up. On examining the deposit, the most valuable will be found in the upper part of the tye, while that at the tail will perhaps not be worth further treatment. The whole series of apparatus is founded on this principle.

The material coming out of the cofes of the stamps runs first down a sloping bed, which will not retain any thing on it and then on to less inclined beds where the mineral is to be deposited. It is an important question as to whether you cannot save something by mechanical means and this it is possible to do in some cases (eg with gold etc) This may be done by placing bulls hide with the hair pointing up the bed as in Brazil - in other cases coarse flannel or canvas or turfs as in Wallachia Where there is nothing to catch in this manner as in the case of the tin stamps, it is usual to run the material out into a series of tyes placed at a very small angle - Sometimes when a specially rich part of a vein is cut the heavier minerals may be deposited so soon as to choke up the passage so that a special box (a 'save') is placed horizontally at the outlet to save the material This apparatus does not give you

as to size as is desirable - so Rittinger devised the
The water carrying the stamped material is
made to flow through a series of four boxes
these have sloping sides so that no material
will rest on them. The matter then deposited (in the
the first) falls to the bottom and there
passes through an opening into a siphon,
the flow through which is regulated by a stop
cock, similarly with the other boxes. To
extract the material it is only necessary
to open the stop cocks and allow a small
stream of water to flow through the siphon -
which will carry out the deposit and
may take it at once to the inclined
planes, thus avoiding any necessity for interrupting
the main flow for the purpose of removing the
sediment. Under various modifications this has
been employed in the Hartz, Saxony and
Hungary - and the division of sediment
according to size gives greater facility in the
subsequent operations

Bennett Hooper Brough.

Lectures on Mining

Prof. Warington Smyth.

Royal School of Mines. 1881.

* * * * *

(60 cont.) In Cornish tin mines something of the same kind has been in use, where the water runs into Conical sheet iron vessels and is made to circulate as as to form a kind of whirlpool, and in this way you may have the whole of the roughs last deposited and only the slime flows away - which can be led off at once to the dressing floors.

The apparatus employed for dressing is to be looked upon mainly as an inclined plane of wood or of late years of glass, cast iron, or Marble (Austrian mines) A ~~mixed~~ stream of pulverized minerals and water being sent over such an inclined plane, the forces acting on the mineral will be - first the impetus of the water which depends on the quantity and the area of surface over which it flows - 2ndly gravitation 3rdly resistance due to friction 4thly the cohesion of the particles among themselves We may divide these machines into 2 classes those with a fixed inclined planes and those with a movable one.

The former may be subdivided into 'buddles' a those which are intended to receive a thick deposit — and 'frames' for only a thin deposit. The simplest buddle as used in the N of England and in W. more used 25 yrs ago than now — readily put up little loss of mineral — It consists of a pit 8-12 ft long, usually lined with timber while above the pit inclined at a considerable angle is a head board down which the water and ore runs to the pit. Sometimes there is a series of pegs on this head board which can be turned about so as to regulate the flow over the board And there may be at the top of the channel a head button, which can be arranged to direct the stream either to the right or left of the head board, so that one side may be in use while the other is being cleaned.

Less satisfactory is the Nicking board of the N. lead mines A quantity of ore in the shape of a thick mud or clay is placed on the head board

and an attendant allows the water from above to flow over the board by sticking the mass of ore with a shovel or hoe in parts so as to regulate the flow and allow it constantly to carry away some of this material in suspension.
The water is made to flow in a series of waves and not in a direct manner, out of the buddle By stopping up holes at the end of the buddle with pegs it will be arranged always to have a tail of water at the bottom end. Care must be taken as deposits are formed that the slope does not become too great and so a quantity of stuff pass down to be lost. The deposit must not be kept tilt too high. When it reaches 12-18 in. ~~ft~~ it is stopped and the sediment taken up in 3 pts. that nearest the top being the richest - heads, middles and tails. A man on a transverse bar across the pit with a besom or hoe keeps working up against the current so as to clear away slime and prevent irregularities

Where the head boards with a series of pegs is used the pulverized ore is mixed with the water, either by a shovel or by machinery and then after passing through a grating to stop chips or large stones which may have got in it is fed through a hopper on to the head board; the rest of the arrangement is like that with the rocking board

In the ordinary 'cradle' there is a circular bed 12ft to 18ft diam. sloping gently towards the circumference and surrounded by a wall. In the centre is a circular area (6ft diam) with sides sloping more steeply than the bed. On the table the mixed ore and water is made to revolve on a vertical axis. The axis also carries a series of cross bars to which are suspended rods of wood or a series of light leather brooms or brushes, or it may be flaps of canvas according to quality of ore. These spread the ore evenly over the floor

but they must be raised from time to time as the deposit goes on so as not to interfere with the material deposited and lead to waste. but only lightly scrape the surface to prevent formation of channels. The mixed material poured on to the upper inclined plane (may regard as the head board) will run down on to the floor of the buddle and there deposit the sediment as heads, middlings or tails In "Slime buddles" a horizontal shaft carries a series of knife blades which cut up the material then on a 2nd axis a series of vanes beat the water and mix — . And on a 3rd axis a series of brushes which as they revolve sweep over a series of small holed grates thro' which the mixed material passes to the inclined planes and thus clear the grates of stones etc. An additional set of vanes may be added if necessary to strike the water and cause it to flow in waves.

A much rougher buddle is used by the slime dressers

where the mixed water and slime is allowed to fall from a trough directly on to the centre of a prepared circular space

The largest buddles at St Just's are 50ft diam. The best diameter for the central portion is about 40ft some think 24ft other half that of the buddle Generally 4-6ft diam.

Of variations we have Hundt's concave buddle In this the inclined plane is placed in the opposite direction, ie it slopes towards the centre and the material is given out by a series of ports placed round the circumference, and there is an arrangement in the centre to prevent water going out with too much of a rush. A series of brushes go round & sweep as before.

From the facility with which a concentrated current towards the centre is obtained washing away the deads very efficiently this form is the better - and if there is much mullock mixed with the mineral it may do very well but there is greater risk and perhaps some practical objection

The other class of machines are the 'Tables'
(used for a long time in Saxony for silver ores)
They are very carefully constructed and placed at a
low angle of inclination with a grating to strain off
chips and stones and a head board with an arrangement
for equalizing the flow of water. In the use of these frames
we must have a supply of clean water to dilute down
to a requisite point the material which has been
mixed delivered by means of a tap into the hopper
from which the material passes to the head board
In some Hungarian mines these frames are 18ft & 24ft
long. A man with a wooden hoe rakes up
against the flow of water during the deposition
And at length the clear water must be introduced
The dirty water is stopped and the clear water
turned on and then with a light brush or hoe
used very lightly the man just sweeps against
the flow and thus a good deal of the
more slimy deposit is got rid of. Then the
lower end of the deposit is removed and afterwards

the upper, sometimes by a trap door in the centre of the frame, more usually one portion after another is led down into little boxes placed at the end. In W. the table is not nearly as long as on the continent - the material flows over a flap on to this table. The latter is supported at top & bottom on pivots in order that it may be turned endways for purposes of clearing - When the bottom boards are covered with deposit the dirty water is stopped

Self acting frames have been arranged so as to allow the material to flow over them for a certain time and then (by the filling of a trough with water or some such method) the frame overbalances and at the same time opens a trap which lets on a stream of clear water to wash off the deposit into proper receptacles

B Class in which the

61 Apparatus is movable.

The introduction — very simple — a movable tray worked by hand — "vanning" Very commonly it is a circular dish or pan made of tinned iron. In our own Districts a "vanning shovel" is used. In colonies "prospecting shovel" in Germany "Sichertrog" The form of the dish varies — in Brazil conical in the centre — in Mexico it is of conical form in the centre, on smaller scale and made of horn and also used for amalgamating — in E. of Europe oblong and of wood.

Apparatus in which an inclined plane is suspended and while a stream of water flows over it, it is subjected to a succession of shocks. Still largely used. A table is suspended by 4 chains, the two longer at one end being attached to the barrel of a small windlass by which they can be raised and the inclination varied The 2 shorter ones at the upper end of the table do not hang vertically

but are inclined and can be adjusted so as to regulate the tension and therefore the strength of the shocks
The method of working is to place cams or other arrangement on an axis so as to push the table a certain distance forward and then release it, so that it will fall back with a sharp blow against a block of wood. "Stossherd" or percussion frame.
The framework is made very strongly, the frame itself is made of transverse boards, very smoothly joined - When the blow is struck solid - ie when the table falls against a solid block (a small block being fixed at the upper end of the table to receive the direct blow) - from 30-48 blows per min may be given. In the Hungarian districts another method is adopted, it falls against an elastic board stretched between two blocks - 10-12 per min but there is a succession of smaller blows due to the rebound. The ore and water are mixed in a separate trunking box and may, if req, be diluted with clear water as it flows down the headboard

As most of the material will tend to be deposited at the upper end the slope of the bed in that part will gradually become greater and might lead to loss from the too great steepness were the inclination not suitably altered from time to time by raising the two long chains. Rittinger proposed a 'continuous percussion frame' In this the suspended table is drawn out of its position sideways and allowed to fall against a block so that there is a tendency to throw the stuff toward the side on which the block stands. Suppose we have mixed ore, when the blow is given the material of greatest Sp.Gr. will be thrown out farthest, the dirty water will more or less keep on in a straight line There will be a more or less efficient separation and difficult classes of material will pass down in curves to separate portions of the end of the table where they are received into separate portions

Another modification took its rise in the Hartz.
The table is circular and the material is started from the centre towards the circumference, usually by means of a very simple annular trough
At a certain time in the revolution the water is let loose to flow as dirty water over the surface and clear water is added to and the division and then on coming to a certain portion of the revolution (a very slow one) it receives additional quantities of water until it has passed sufficiently far as to be spread and you are prepared to run it off as tails, middles and heads into troughs round the circumference. The whole table is moved round at the rate of one revolution in 8, 10 or 15 minutes — the stuff should be entirely cleaned in one revolution. The stuff can be cleaned and rendered marketable in $\frac{1}{7}$ of the time by the long fixed tables. The water passing from the table must be tested from time to time to see that nothing valuable is being lost.

Apparatus for finishing.

The ore is now carried to the "Kieve" a barrel or open tub, 3 to 3½ ft high, 3 ft diam. and a quantity of material in its nearly clean state is thrown in, and agitated along with water by means of a shovel working it up till it is brought into complete suspension. The shovel is then withdrawn and a boy is set to strike the kieve with a bar of iron so many times a minute and the consequence will be the settlement of the material according to its character, the most valuable at the bottom to be sent to the smelter. In N. a dolly-tub arrangement is used - rotatory motion being given to a set of vanes arranged on a vertical axis to effect the agitation. The material is allowed to subside, and then, the water is drawn off or allowed to flow away through peg holes in the sides of the kieve and the material taken out in strata as before

Passing back — we come now to the pieces of ore which vary in size from a walnut to a pea — in which the sieve will do good service. In the Flintshire lead mines very little dressing is required beyond breaking down the material by hand, placing in a sieve and moving it up and down in water. To get the larger quantities it has been usual in the Co and PB mines to employ a "Brake sieve" a rect. sieve of wires or punched plate. The sieve is attached to a frame which is moved up and down by a long lever — the whole is called a "Jigging sieve" The sieve is 4 ft × 1½ ft wide. The top stampings are first taken off, then the next deposit may have to be separated into 2 or 3 and set aside for further treatment then there is the bottom richer ore, a portion of which must be left for the bed. That which falls through into the box or hutch is usually rich ore.

Pettenicki's Patent Separator - not universally adopted in England

4 circular sieves were placed in as many openings in the top of a large box and in the middle was another hole in which a small piston was moved up and down with a stroke of 3 in. The box being filled with water the movement of the piston caused the water to strike against the sides. The separation was admirable. The jigging process has been carried much further on the continent. One modification is that where you have a square piston moved by an excentric to strike the water. And the opening between the piston and the sieve regulated by a door. Rittinger introduced a machine on this principle which works continuously. The chamber in which the piston works communicates with a reservoir of water on one side of it by means of a set of valves opening towards the former chamber, on the other side there is free communication with the chamber at the top of which is the sieve.

The downward movement of the piston closes the valves and drives the water into the sieve chamber. The sieve is placed slightly inclined, so that when the particles are lifted the heavier ones will have a tendency to run to the lowest part of the sieve. As they pass downward the inclined sieve little horizontal tongues at the edge divide the different layers and conduct them into different receptacles, and this goes on continuously

A similar machine has been used for washing coal, only in this case it is the lighter portion which is the most valuable.

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Metallurgy of Silver and Lead. By R. H. Lamborn. $1.

Treatise on the Metallurgy of Iron. By H. Bauerman. $1.80.

Lectures on Mining, Delivered at the School of Mines, Paris. By J. Callon, Inspector-General of Mines. Translated at Author's Request by C. Le Neve Foster, D.Sc., and W. Galloway, H. M. Inspectors of Mines. In three volumes. Vol. I. London and Paris, 1876. 8vo, pp. xix and 459. Atlas of Plates. 4to; forty-four plates. Vol. I. and Atlas, $13. Vol. II. 1881. 8vo, pp. xiv and 540. Atlas of Plates. 4to; fifty-four plates. Vol. II. and Atlas, $13. The two vols. with the Atlases, $25.

Conversation on Mines, between a Father and Son. By Wm. Hopton. $1.50.

Mining, its Theory and Practice, by J. M. Stuart, M.F. Illustrated. $1.

Mining Machinery. By G. André, F.G.S. 2 vols. Plates. $28

A Practical Guide for the Manufacture of Metallic Alloys. Translated from the French of A. Guettier. By A. A. Fesquet. $3.

Steel, its History, Manufacture, and Uses. By J. S. Jeans, Secretary of the Iron and Steel Institute. London, 1880. 8vo, 860 pages. 183 engravings. $14.50.

Underground Treasures : How and Where to Find them. A Key for the Ready Determination of all the Useful Minerals within the United States. By James Orton, A.M. 1872. Small square 8vo, 137 pages. Illustrated. $1.50.

Manual of Hydraulic Mining. For the Use of the Practical Miner. By T. F. Van Wagenen, E.M. 12mo., 93 pages. $1.

The Explorers' and Assayers' Companion: Rocks, Veins, Testing and Assaying. Vol. I. (Complete in itself.) By J. S. Phillips, M.E. 1879. 8vo. cloth, illustrated; pages xiv.+468 (including 46 pages of Glossary) *This is Vol. I. of the third Edition of Explorers', Miners', and Metallurgists' Companion.*) Library size and pocket size; either size, $6.

The Explorers', Miners', and Metallurgists' Companion. A Practical Exposition of Geology, Exploration, Mining, Engineering, Assaying, and Metallurgy. By J. S. Phillips, M.E. Second Edition. 1873. 8vo, cloth, illustrated; pages xv.+671. $10.50.

Roasting of Gold and Silver Ores, and the Extraction of their Respective Metals without Quicksilver. By G. Kustel, Mining Engineer and Metallurgist. New Edition, 1880. Illustrated with Numerous Engravings. 8vo, 156 pages. $3.

ROADS.

The Principles and Practice of Road-Making. By W. M. Gillespie. Ninth edition. Cuts. $2.50.

A Practical Treatise on Roads, Streets, and Pavements By Q. A. Gillmore. Illustrated. $2.

TRANSACTIONS.

Transactions of the American Institute of Mining Engineers. Vol. I., May, 1871, to February, 1873. Vol. II., May, 1873, to February, 1874. Vol. III., May, 1874, to February, 1875. Vol. IV., May, 1875, to February, 1876. Vol. V., May, 1876, to February, 1877, *with a General Index to* Vols. I. to V. Vol. VI., May, 1877, to February, 1878. Vol. VII., May, 1878, to February, 1879. Vol. VIII., May, 1879, to February, 1880. Vol. IX., May, 1880, to February, 1881. Strongly and neatly bound in half morocco. Price, $5.75 a volume ; $5 unbound.

WEIGHTS AND MEASURES.

Tables of Weights, Measures, Coins, etc., of the United States and England, with their Equivalents in the French Decimal System. Arranged by T. Egleston, Prof. of Mineralogy and Metallurgy, School of Mines, Columbia College. 1880. Thin 18mo, $1.

Useful Rules and Tables relating to Mensuration, Engineering, Structures, and Machines. By William John Macquorn Rankine. London. Sm. 8vo. $3.50.

MISCELLANEOUS.

Play-Book of Metals. Illustrated. $2.25.

Workshop Receipts, for the use of Manufacturers, Mechanics, and Scientific Amateurs. By Ernest Spon. $2.

Report from the Royal Commissioners on Internationa Coinage. $2.50.

amount of completeness and accuracy. Curt and vague answers will be but of little value, and exactness will be expected in all that relates to numbers, prices, weights, and measures.

Those who wish to gain a general knowledge of the topics for examination may be recommended to direct their attention to the subjoined heads, viz. :—

First Stage or Elementary Course.

1. Geology and Mineralogy, more particularly those portions of the sciences which bear on the following subjects,—the nature and position in the earth's crust of the useful minerals, the classes of rock with which they are severally associated, the special character of heaves, throws, troubles, and all kinds of dislocation; the particular differences between beds and lodes, and their minerals, and the chief features of irregular repositories.
2. The methods of prospecting and searching at surface for ores and other minerals.
3. Breaking rock by manual labour alone; various forms of pick, and of hammer and wedge employed for the purpose. Use of gunpowder and other explosives; precautions to be observed in boring and in firing shots.
4. Depths attained by mines and bore holes in various cases. Geographical distribution of the chief mining districts.
5. Ventilation of mines, why important. Composition of air, carbonic acid gas, and fire-damp; how the latter noxious damps occur, and what precautions against them should be adopted, either for a temporary purpose or permanently. Reasons of a natural circulation of air to some extent being observable in all mines. Various applications of water to aid ventilation. Means of applying heat, or machines for the same purpose.
6. Lighting of workings; principle and construction of the safety lamp.
7. Circumstances under which water enters mines. Working of ordinary pumps; special requirements of pumps for mines. Mode of applying human or horse labour to the winding of water and stuff or mineral; fixing and comparison of the unit of work. Waterwheels and steam engines, variety and construction of, as in use for mining purposes.

   Carriage or conveyance along levels and inclines; barrows, tramplates, rails, tubs, or wagons.

   General features of winding in shafts by machinery.
8. The form and dimensions of shafts applied to various purposes; sinking, and precautions against accident from falls and from collapse of sides.
9. Driving of levels, drifts, and wind-roads; their rate of inclination, breadth, and height in various districts; methods and cost of arching them, and of timbering or wooding.
10. The removal or *exploitation* of mineral after completion, to a certain point, of dead work; stopes and pitches, under various circumstances. Pillar-working at various depths, and other forms of extracting coal or ironstone. Main considerations of safety and economy which have to be studied in adopting a particular plan.
11. Means of security to be adopted in shafts; 1st, as to construction and fixing of ladders; 2nd, as to rules and arrangements where the men ride instead of climbing.

Second Stage or Advanced Course.

1. Details as to the form in which the useful minerals are accumulated; stratified deposits; alluvial or stream-works; lodes and their various directions; pipes and other irregular repositories. Examples of remarkable localities; true sectional drawings or profiles to be studied. Examples of heaves, and alleged laws according to which they have taken place. Composition and physical state of the containing rock or "country."
2. Exploring, shoading, and costeaning. Grounds for opinion in the re-opening of old mines; preliminary operations in virgin districts.
3. Breaking of ground; the various implements employed, their form, dimensions, and weight; boring for shots; the various modes of firing charges. Heavy charges, how calculated and fired; rules for ensuring safety. Drilling and coal-cutting machines.
4. Deep boring, under what circumstances applicable,—apparatus for; description of varieties in use; lining of bore-holes.
5. Management and supervision; payment of men employed at mines, at surface and underground, varying in principle with the different classes of operation; reasons for tut-work or piece-work, and tribute or bing-tale under different circumstances. Calculations for cost of driving, sinking, tramming, &c.
6. Physical principles of ventilation; practice of mines where simple natural ventilation is employed; ventilation of large areas and of deep or complicated workings by guiding the natural current; artificial means, and their details, for promoting ventilation. Precautions to be taken under specially dangerous conditions.
7. Illumination, of various kinds, their economy; safety lamps in all their best modifications; circumstances under which they should be employed; precautions in their use.
8. Mechanical division of the subject. Strength of materials used in mines; human and horse power, principles and construction of machines to which they are applied. Hydraulic machines; construction of the water-wheels, turbines, and pressure engines most suitable to the various operations of mining. Steam engines, for pumping and for winding; arrangement and construction of the varieties most in use. Form and dimensions of boilers. Pumps employed in mines, mode of placing them; construction of the lifts; materials and details of the rods, set-offs, counterbalances, cisterns, and catches. Circumstances under which dams are erected in shafts or levels; mode of building them.

   Tubbing of water from shafts; conditions under which it may be done; details of the operation with various materials, wood, brick, stone, cast and wrought iron.

   Rails, waggons, and tubs for underground conveyance; employment of horses and of fixed steam engines for this purpose.

   Raising of the mineral through the shafts; various methods in use; chains, ropes (of hemp or wire), their weight, &c. Details of the best application of drums, cages, guides, keeps, and safety doors. Pulleys and shaft frames or poppet heads; protection against overwinding; safety clutches, &c. in case of breakage of rope.
9. Opening of ground; quarries and open work; driving of levels, various dimensions and directions according to circumstances; sinking of shafts, inclined or perpendicular; advantages of either kind under certain conditions; means of securing levels and shafts by timber or by walling; details of the various methods. Driving or sinking in heavy or running ground.

10. Working excavations; plan of laying them out, and means of security to be adopted whilst they are kept open. This will include the stoping of metalliferous veins, and the various modifications of post and stall, long-work, &c., which are applied to stratified deposits.
11. Travelling in shafts; prevention of accidents by proper fitting and dividing; mode of placing ladders and sollars; lifting machine for men, construction and advantages of.
12. Dressing of minerals. Arrangement of dressing floors. Construction of crusher and stamps; washing of coal; jigging, concentration, and separation of metallic minerals.

Examination for Honours.

Questions will be set at the discretion of the Examiner, who will have regard to a general knowledge of mining as carried on in this and other countries, and may require certificates from employers as to practical work.

Text Books.

The student may be advised among other sources of information to consult the following works:—

Manual of Geology, by J. Phillips. 8vo. 12*s.* 6*d.*
(London, Griffin, 1855.)

Report on Cornwall, &c., by H. T. De la Beche.
(London, Longman & Co., 1839.)

Laws regulating the Deposition of Lead Ore in Veins, by W. Wallace. 8vo. 25*s.* (London, Stanford, 1861.)

Treatise on Mining Engineering, by G. C. Greenwell. 4to. 50*s.*
(London, Spon, 1856.)

Coal and Coal Mining, by W. W. Smyth. 8vo. 7*s.* 6*d.*
(London, Strahan, 1869.)

Metallic Wealth of the United States, by J. D. Whitney. 8vo. 16*s.*
(London, Trübner, 1854.)

Mining and Metallurgy of Gold and Silver, by J. Arthur Phillips.
(London, Spon, 1867.)

Miners Manual of Arithmetic and Surveying, by W. Rickard.
(London, Longman, 1859.)

Géologie Appliquée, par A. Burat. 2 vols. 8vo. 17*s.*
(Paris, Langlois, 4th ed., 1859.)

Die Lehre von den Erzlagerstätten, von B. von Cotta. 2 vols. 8vo. 15*s.* (Leipzig, Felix, 2nd ed., 1861.)

Besides these the various reports of H. M. Inspectors of Coal Mines, and the evidence given before Committees of the Houses of Parliament on *Accidents in Mines*, may be studied with advantage.

Works on Mining, in addition to the above list, which should be kept for reference in a library:—

Section of the Strata, &c., by Westgarth Forster. 1821.

Transactions of the Northern Institute of Mining Engineers.

The Waterworks of London, by Colburn and Man. 7*s.* 6*d.*
(London, Spon, 1867.)

Exploitation des Mines, par C. Combes. 3 vols. 8vo., and Atlas of plates. (Paris, 1844–46.)

Mineral Veins of Swaledale, by Lonsdale Bradley. 8vo., 21*s.*
(London, Stanford, 1862.)

Memoirs of Geological Survey of Great Britain. Vol. I., 21*s.*; vol. II., 42*s.* (London, Longmans, 1848.)

Lehrbuch der Oberflächenformen-Kunde (drawing of ores)
by Rittinger (Berlin Construction 1867)
Geology of Sandander and Madrid by Sullivan
and O'Reilly 10s- (Williams & Norgate 1863)
History of the Coal trade by Matthews Dunn
Winning & working of coal mines "
Goldfields of Victoria - Brough Smyth 1869 25s
Hilsdermann

Mining literature.

Notes on Clausthal lectures. Mining Journal 1877-8-9.

J H Collins 'A first book of Mining and Quarrying. (Crosby, Lo

W. Morgans' Manual of Mining Tools (with Atlas)

G. G. André' Mining Machinery (E & F. N. Spon)

(Rock boring) Darlington 'Lecture on Rock boring machinery

M. Journal. Dec 14. 1878.

Raymond - Statistics of Mining W. of the Rocky Mts.

Washington. 1870.

Leslie - Observations on Machine Rock boring.

Schram - The application of Machine power to (Spon)

Rock drilling - G H Hill. Westminster Rd. 1878.

(Drainage & pumping) J. Bourne on the Steam Engine

Smyth's Coal Mining - S Hughes. Water works - (Lockwood

Husband - Lecture on Pumping Machinery. M. Journal

June 22 - 1878.

Werner's New Theory of Mineral veins.

R.W. Fox On Mineral Veins

De la Beche's Geology of Cornwall

Von Cotta on Mineral veins.

Salmon " "

Henwood's Metalliferous deposits.

Metallic contents of lodes.

Affected by nature of strata - In N. Wales hard blue slates of Llandeilo favourable for Pb - Also prevailing ore in limestone -

Alternation of freenstone & porphyritic rocks with slates produce Cu - Granite prolific for Tin -

Metallic ores occur in lodes in a variety of ways, as 1

Sprinkled in the midst of solid quartz

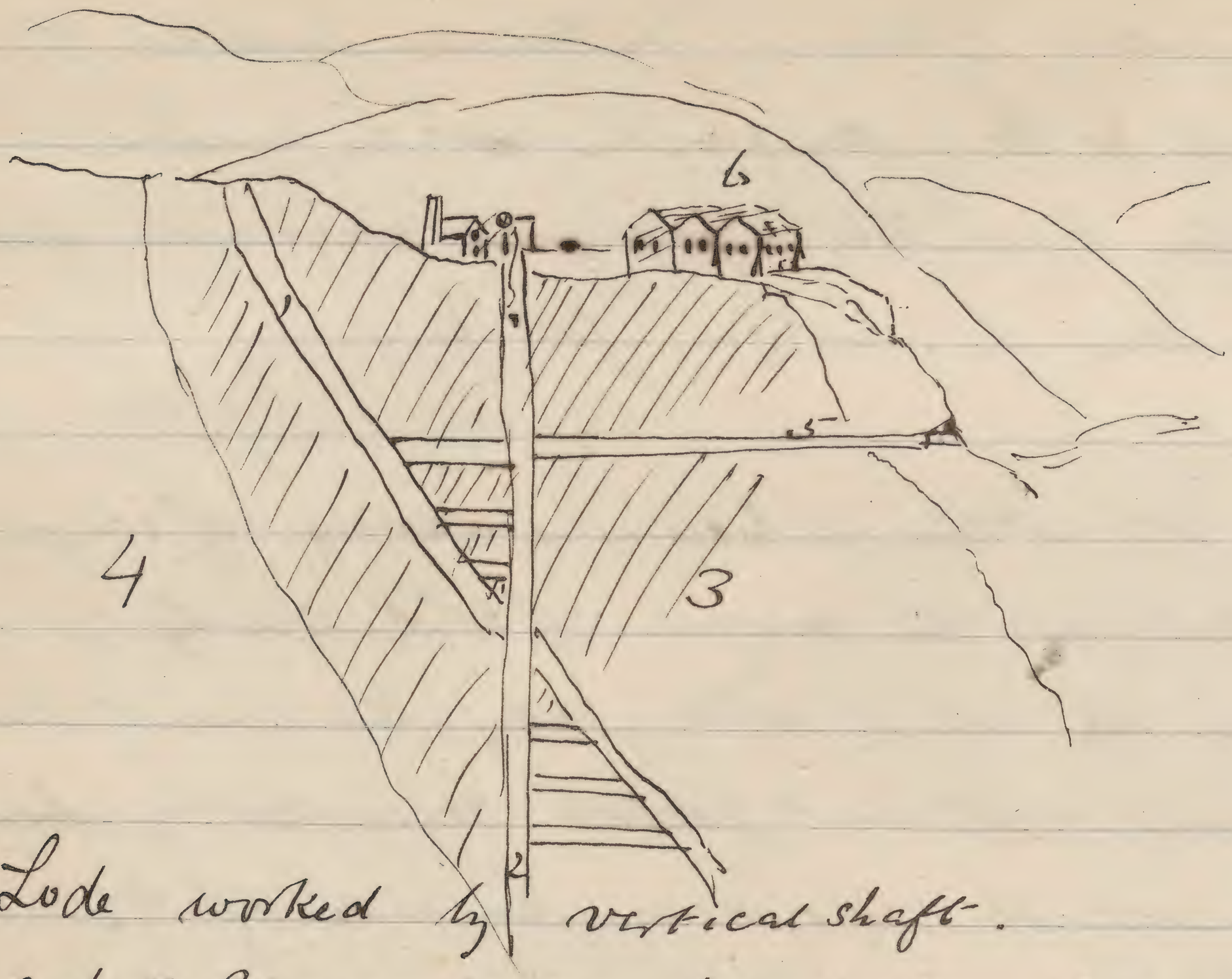
2 filling up as a solid body the whole of the crack.

3. forming nests and pockets connected by strings

4 considerable deposit on one side of the lode

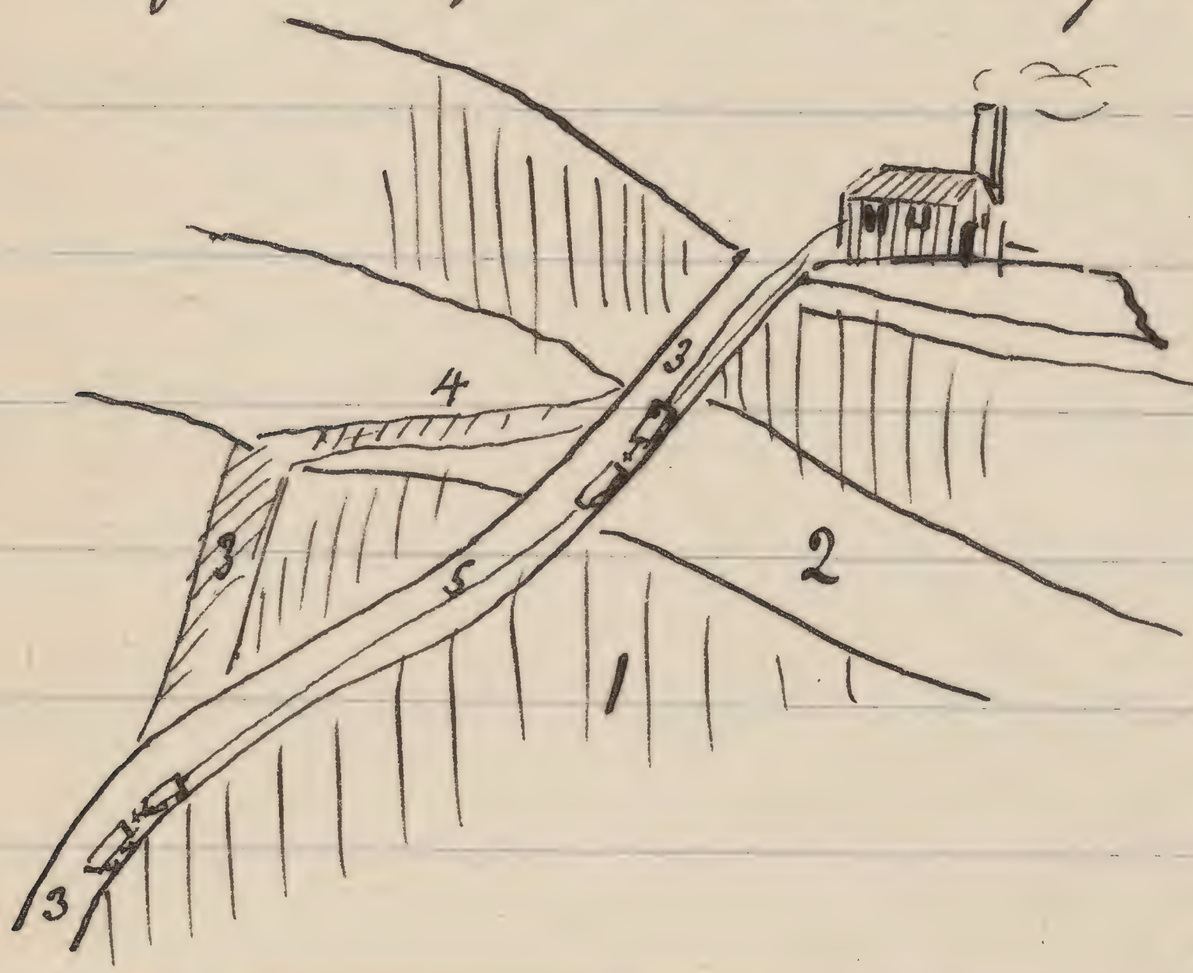
5. irregularly dotted over the whole width.

6 in regular layers



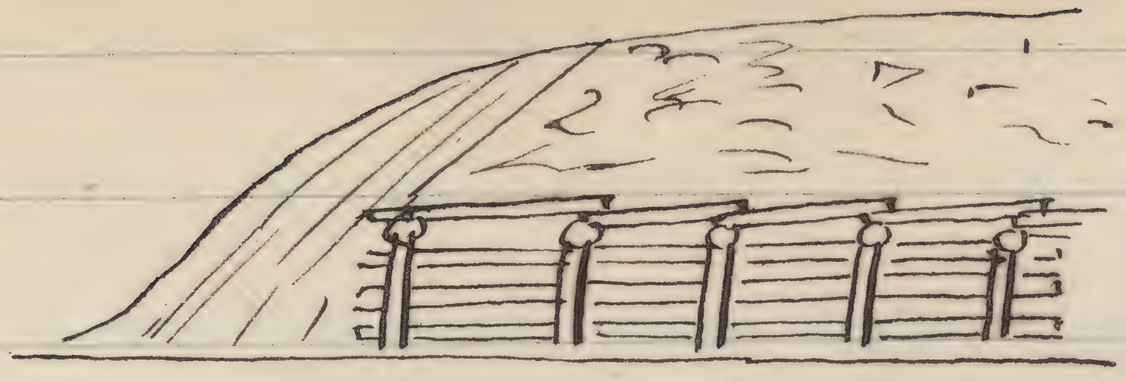
Lode worked by vertical shaft.

1. lode 2 shaft 3 unproductive 4 productive strata 5 adit 6 dressing sheds.



Lode worked by diagonal shaft.

1 productive
2 unproductive
3 lode
4 fault
5 continuation of shaft to meet lode.



Section of Entrance to Level Showing method of timbering

Long capacious district tunnels.

Blackett Level – 1850 nearly 7 miles long.

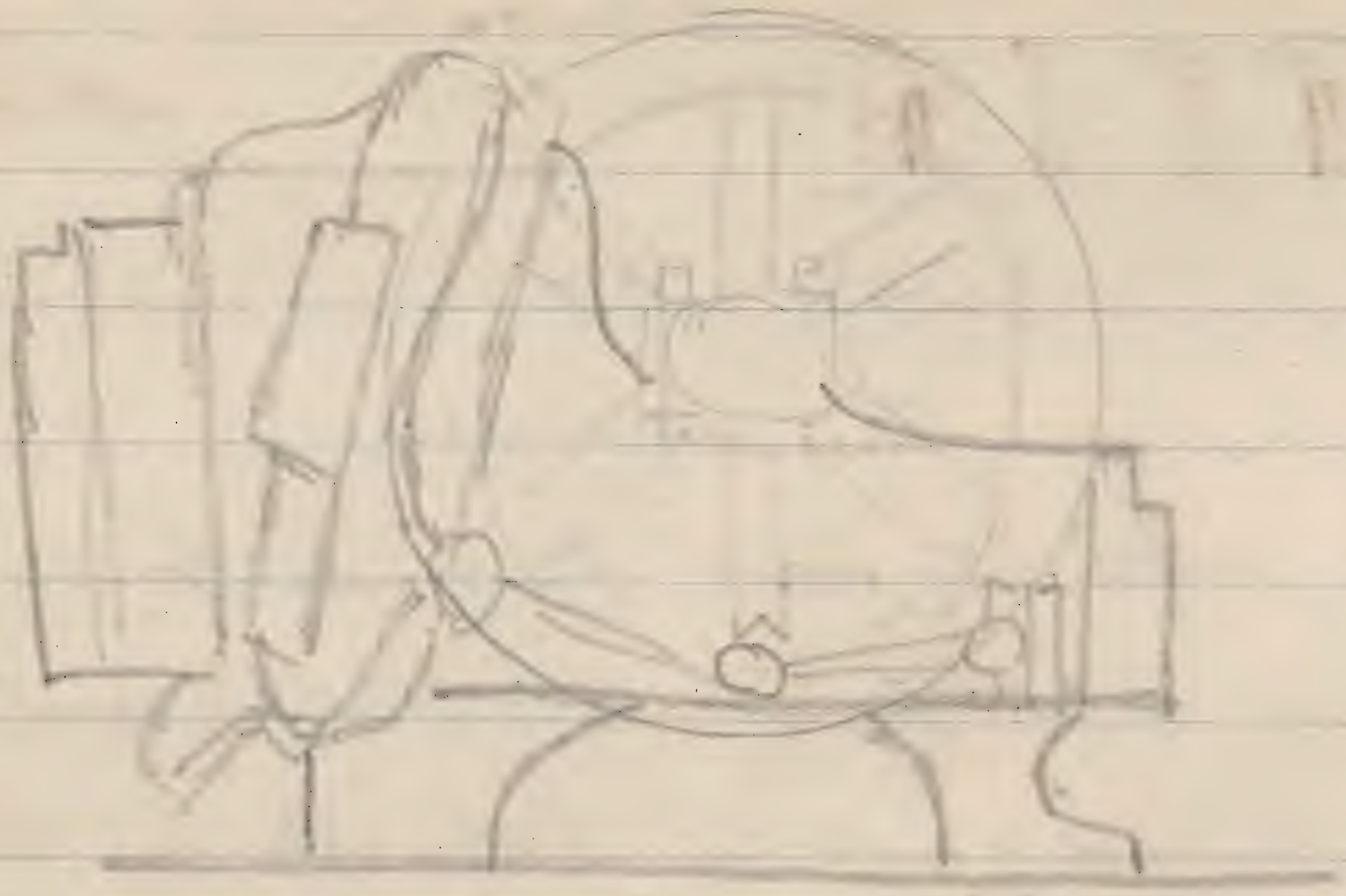
Halkyn drainage level will be about 7 miles long

At Redruth tunnel with its branches is 40 miles long

In Germany there is the Ernst August tunnel begun 1850 14 miles long 1200 ft beneath Claustal Church

Rothschönberger Stollen – near Freiberg 8 miles long.

In Schemnitz The Emperor Joseph tunnel is 9 miles



Plastic Stapler

Mines of the Hartz. (Ure)

Hartz, a country of forests extending a great many miles round the Brocken, a mountain 55 m. W.S.W of Magdeburg. (3678 ft)

Hartz 43 miles long from S.S.E to N.N.W. 18 m. in breadth, above 450 sq m. of surface. Hilly and covered two thirds over with forests of oaks, beeches, and firs. (Silva Hercynia of Tacitus)

Most common rock is Greywacke - It incloses the principal veins, is associated with clay slate, Lydian Stone, or Siliceous slate and greenstones and is succeeded by a limestone, with a large proportion of the slaty beds, to the Devonian system. The granite of which the Brocken is formed supports all this system of rocks forming as it were their nucleus.

The veins of Pb, Ag, Cu do not pervade its whole extent. They occur chiefly near the towns of Andreasberg, Clausthal, Zellerfeld, and Lauthental. are generally directed from E to W, and dip to the N.E. in Andreasberg, and to S in the Clausthal district at an angle of about 80° with the horizon.

Richest Silver mines are those of Andreasberg. Samson and Neufang mines, 2740 ft deep. In first is the greatest step exploitation to be met with in any mine. Composed of 80 underhand stopes, no more than 630 yds long.

Mines discovered 1520, city built 1521.

Clausthal yields most argentiferous lead. Dorothea and Carolina most remarkable. It was in order to effect the drainage of the mines of Clausthal and Zellerfeld that the great Adits have been excavated. Below George III's deep adit (Georg Stollen) a still deeper (Ernst August Stollen) and a water level is now in course of construction 126 fms below the deep Adit (320 fms below surface)

Rammelsberg - Copper mine since 968 - On a mass of Copper pyrites, disseminated through Quartz and mingled with Galena & blende Gold to the extent of the 5-millionth part of the mass explored and yet means are found to separate it with advantage. Great many iron mines in the Harz.

At S. foot of Harz at Mansfeld, is a mine of Manganese.

The exploration of the Harz mines may be traced back 900 yrs. Epoch of greatest prosperity was the middle of 18th century. Some of these mines are worked by the Government, others by companies of adventurers. They are celebrated for the excellence of their mining operations, for the systematic application of the processes for dressing the ores and for the activity, patience and skill of their workmen.

Waters are collected and economised for floating down the timber and impelling the machinery. Dams & lakes, canals, aqueducts have been constructed remarkable for their good execution. Watercourses either in the open air round the mountain sides or through their interior as subterranean galleries. The open channels collect the rain waters and from the melting of the snows, from the springs and streamlets & small rivers that fall in their way. The subterranean conduits are in general the continuation of the preceding whose circuits they cut short. These watercourses present a development in all, of above 125 miles. The banks of some of the reservoirs are of an extraordinary height. In Carnthal alone there are 63 ponds, which supply water to a great no of overshot wheels, of those attached to the mines 46 are at the surface - 21 and 3 water pressure engines underground, 50 wheels to the dressing machinery, 39 to the smelting furnaces.

Schmidt's law. You first observe the point of intersection of lode and heave & then their angle of inclination. The next problem is to find out the plane of intersection of these two. This is done by means of setting off distances parallel to lode and cross heave, which are obtained by dividing the height of level from the point below where you are looking for the dislocated part by the tangent of the angle of inclination of the lode and of heave. These lines being then drawn parallel to lode and heave will by their intersection give you another point in the plane desired. You then connect these points and strike a pp. through the point of intersection, and on whichever side of the plane it falls that will be the side on which the dislocated part will be found.

(Mines of E of Germany.

The Erzgebirge contain a great many mines, Ag, Sn, & Co.

Silver mines are opened on veins which traverse Gneiss).

Lead Mining in Derbyshire (Transactions of the Chesterfield and Derbyshire Inst. of Mining Engineers. June 1880. VIII. 1)

The old customs and rights are detailed in a poem by Ed. Manlove + printed in 1653 ; in a book called " the Liberties and customs of the Mynors 1645, and the Articles and Customs of the King's field in the High peake 1601. The compleat miner by Thomas Houghton London 1681.

A.H. Stokes on Lead mining in Derbyshire.

Plans. The greater part of the mines have no plans whatever, and at those larger mines, which have plans, they are either very roughly done, or do not indicate the extent to which the ore has been worked. In lead mining, the plans are of two descriptions, viz, those showing the workings of the rake veins and those showing pipe or flat work. In rake veins a separate plan should be made for every 10 fms, or at such distances as the levels are apart. In this way a series of plans would give a true representation of the underground workings, and be clearly understood by any engineer visiting the mine, whereas in some cases, the plan now made is a series of single lines, showing the line of sight of the instrument, and these are on the top of the other, crossing and recrossing, forming a

trigonometrical problem only to be solved by the person who made the same. In plans of flat or pipe work, it is essential that the variable width of the work, after the ore has been extracted should be shown, so that the geographical position of the various branches be clearly indicated, but at the present time, the best plans merely show a double coloured line, and the position of the best and most profitable parts of the mine or the width to which the ore has been extracted is all shown as ordinary narrow heading. It might almost be said that the plans are not true representations of the working of the mine, but simply represent the extent of the tramways underground. Sections of the mine are seldom made, and levels usually are ~~made~~ kept by the water made in the mine

LECTURE XX.—Having examined (said Mr. SMYTH) the implements for, and methods of, breaking ground, we next come to the modes of paying the workmen. This is a subject well worthy of consideration, on account of the advisability of obtaining at the same time the maximum of economy and the maximum of work we may get from men able and willing to do all that can be fairly expected of them. So large a proportion of the expenses of a mine are absorbed in the mere working away of the rock, and other kinds of manual labour attendant on it, such as wheeling away the mineral dislodged, and the dressing of the mineral when it comes to the surface, that it is a matter of importance not only to prevent too much being paid, but that the men may be kept to their proper work, and not as by some methods be actually demoralised by the mode in which they are paid. In mines of all kinds there are different grades, regulated by the different degrees of intelligence required, and paid accordingly. Thus, the manager and over-looker are paid by the week, the month, or the year, while others ought to be paid by the real actual amount of work they perform in a given time. If we compare the working of a coal mine with that of a metallic mine we shall have to remember that great differences exist as to the character of the work, and whether the mining is done on a large or on a small scale. If we take two examples from our own mines, and select in each case one on a large scale, we shall find the comparison as follows :—

COLLIERIES.		METALLIFEROUS MINES.
Chief viewer	corresponds with ..	Inspecting captain and manager.
Resident or under viewer and overmen	,, ,,	Chief resident captain and sub-captains; grass captain, who has charge of surface arrangements.
Deputy overman	nearly parallel with	Pitmen or shaftmen.
Waste men—whose duties are most important in fiery mines	,, ,,	Timbermen—who put up the supports to the roof and sides.
Fireman—his duty is to go round to all the workings before the men, to see that all is safe	,, ,,	No equivalent.
Hewers—the actual working miners, who cut the ground	,, ,,	Tributers and tutworkmen.
Putters and rolley drivers....	,, ,,	Trammers.
On-setters or hangers-on	,, ,,	Fillers.
Doorkeepers or trappers.....	,, ,,	Not needed.
At the surface—		
Banksmen	,, ,,	Landers.
Screeners	,, ,,	Dressers.
Smiths and carpenters	,, ,,	Smiths and carpenters.
Enginemen	,, ,,	Enginemen.

Besides these, will be to each the staff belonging to the office, as clerks and business managers. The purser in Cornwall is the man who has the expenditure of the money.

In one of the largest mines in Saxony (Himmelsfurst), where 754 persons are employed, the work is apportioned in a very similar manner—1 surface captain (ober-steiger), 1 underground ditto, 16 under captains (showing that supervision is greater in continental mines than our own), 362 miners and hewers, 54 timbermen and masons, 122 trammers, windlassmen, and fillers, 171 dressers at the surface, 21 smiths, 3 enginemen, 2 watchmen, and 1 clerk ; total, 754. In our own country a mine of similar size and character employs 1098 persons, as follows :—Agents, 10 ; pitmen and timbermen, 11 ; tutworkmen, 250 ; tributers, 19 ; trammers, fillers, and landers, 74 ; labourers, or simply assistants in this sort of work, 9 ; boys, 21 ; making underground a total of 394. But at the surface there were—agents, 9 ; smiths, 18 ; carpenters and sawyers, 19 ; masons, 12 ; enginemen, 15 ; labourers, 111 ; foundry and on railway, 37 ; dressingmen, 122 ; boys, 157 ; girls and women, 204 : total, 704, making together, 1098.

There is, you will see, a great deal of work to be done at the surface, and it generally finds employment for the old men and boys, women and girls, who are to be found in every district, as well as the men who do the hard work down below ; and a large mine, therefore, is always, if fairly prosperous, a great blessing to any neighbourhood where it is found. It is evident that for the work of supervision people must be paid by time, and in coal mines that is generally done by the week or month ; but all attempts to pay the workmen by time have

proved unsatisfactory, and it is generally conceded that when men have to work by themselves in remote places it is better to reckon by the work done, or the "piece." The rate at which such payments are made necessarily differs with the nature of the work. The men generally work in shifts of eight hours. Supposing it is agreed that a man shall bore holes and fire so many shots in his shift, the person charged with the supervision must not be satisfied if he hears the shot that the work is done, for it is by no means uncommon for an idle and dishonest workman to so tamp the hole as to make it go off like a gun, and then to make it serve again, and, perhaps, a third or a fourth time. In such cases there is the report of the explosion, but no corresponding effect is produced on the rock. Even in quarrying, when the work is in the light of day, and supervision is comparatively easy, the over-looker must gauge the depth of each hole before it is charged, or, if his neglect to do so can be counted on, it is more than probable that the holes will be far short of their proper depth; and he ought also to see that they are put down at the proper place to produce the best results. It is, in fact, impossible to get a fair amount of work out of the men without interesting them in their labour. With regard to hours, two shifts (each of eight hours) per diem is the rule, but when there is unusual expense in keeping up the engine-power a night shift of another eight hours is often organised, so that the machinery is kept going during the whole of the 24 hours. This is frequently the case in making shafts, whether from the surface or within the mines themselves, for opening out pieces of new ground in search of fresh courses of ore. It sometimes happens that working places are so restricted in room and the men have to labour in such constrained attitudes that it is better to have four shifts of six hours each, the number of men employed under such difficulties being two or three, or at most four, at a time. The hours of inspectors may be carried on for a greater length of time, and the men at the surface work 10 or 12 hours. In coal mines affairs are greatly different in various districts. It is important as regards the safety of the men to consider whether they should be required to work one shift or two. In the North of England the men go to work as early as 3 A.M., so that by 10 or 11 o'clock the first shiftmen have done, and have the remainder of the day for rest and amusement. These are succeeded by a second shift, who come out in the evening; and other men are employed in setting timber props, while some work on the roadways, keeping them clear and open. In Wales the men will not consent to this system, and all go down for one shift per diem. It thus happens that if an accident occurs the lives of all are endangered, while in the North of England half at least escape. In other cases men are employed specially on particular portions of the work, as, for instance, while in one colliery the men have to hole, or kirve, and cut down, in another one set will be employed to hole and a different set to wedge down or shear. The ordinary system in metalliferous mines is to make bargains, and to pay according to the progress made. This is called tutwork, or dead work; and if you ask the question you will be told that there are so many dead-men at work there. Todtwerke is a German word, corrupted here into tutwork. Winzes or small shafts have frequently to be sunk from one level to another, and the bargain may be to sink these, and to remove a certain height and length of the vein. This sort of arrangement is called fathom-tale in England. Great judgment is requisite in the agent who has to make these bargains. It is, generally speaking, by the fathom, and the price will depend on a greater variety of conditions.

1.—The size of the shaft or excavation, which, as it may be larger or smaller, will vary the price paid. The medium size of a level may be put at 6 or 7 feet high and 4 feet wide: if it should go beyond those dimensions the enlarged space will make a serious difference, and if below it will not be economical to attempt the use of gunpowder.

2.—The actual hardness of the rock.

3.—Its jointiness, and whether it is vughy or cavernous.

4.—Whether it is wet or dry, as it not unfrequently happens that the miner has to work in places streaming with water, which is not only unhealthy and inconvenient, but makes the progress very slow.

5.—The price of living in the district, a matter of considerable importance in new countries where prices may be of an exceptional dearness.

6.—The depth from the surface and the state of ventilation in which, if it be in a good state, the men do better work, with the same amount of labour.

7.—The nearness or remoteness of the miners' dwellings, as those who have far to come cannot be expected to do so much work as those that are close at hand.

8, and lastly.—The distance the material has to be conveyed, and whether the tramming is included in the bargain.

It is common in all mines to supply the materials needed by the miners, such as gunpowder, candles, oil, safety-fuses; and commonly the tools and smiths' charges—and all these have to be paid by the men out of the lump sum contracted for. These and the subscriptions to the sick club and burial funds and the schools are paid nominally by the men, but the wages being calculated a little higher for the purpose they are really paid by the proprietors. These things are well managed in some districts, but in others they do not work so smoothly, and some alteration of the system seems to be necessary. Then, again, the quantity of work is what is called "stinted." Thus the price would be so much per

fathom while the ground is of the same character, but when it changed there would be a fresh stint. These "tutwork" bargains are often taken by several men in partnership; and suppose there were six men in such an arrangement their bill would run in this wise: "Such and such a mine to John Jones and Co., 3 fms. 3 ft., at 9*l.* = 31*l.* 10s." Then from this will have to be deducted—40 lbs. candle, at 8d. = 1*l.* 6s. 8d.; 62 lbs. of gunpowder, 1*l.* 11s.; safty fuses, 6s.; sharpening tools, 3*l.* 4s.; doctor's fund, 2s.: total, 6*l.* 16s. 8d., leaving a balance of 24*l.* 13s. 4d. to divide between the men.

It is obvious that nothing but thoroughly knowing the nature of the work, and what men can do, will enable a manager to make proper bargains. The ground being squared up, it is examined by the men, and then put up, as it were, at a sort of auction to the best bidder, so that if one set of men are unwilling to undertake the work others can come in and take it. This is very fairly managed in the south-western districts. The manager invites offers, and the first bidder will offer to do the work at (say) 15*l.* per fathom; then another will say 12*l.*, and so on, until the manager or agent thinks a fair price has been arrived at, when he throws down a pebble, which is equivalent to the fall of the auctioneer's hammer, and the bargain is closed. If the ground proves easier than was expected the men are enabled to get a larger amount of wages than was apparent on their bargain, but on the other hand, if the ground goes against them they have to work harder or get less money than they counted upon. If, however, the manager is convinced the men are doing their best he will judiciously give them a better price next month, and so make it up to them. The men, however, are mostly good judges of what the ground is likely to be, and seldom or never make a bargain which would be absolutely disastrous to them. There are modifications of this plan which come into play in the case of materials of which large quantities are required for sale, as coal, in getting which the men are often paid by weight; or in slate quarries, where the amount of rubbish is enormous, where they are paid by bulk. In collieries men undertake to cut the coal and put it into tubs at so much per ton or tram, which is the same thing. Every tram must be fairly filled, without smalls or rubbish, and when it reaches the surface it is weighed by a man appointed for the purpose, and the men, if they chose, can employ a check weigher. All, then, that the manager at the top has to do is to see it is coal that is sent to the surface, but if any workman is careless or dishonest enough to load with stone amongst the coal the manager has a right to reject that tub, and so the weight of what coal is in it is lost to the workmen. They know, however, well enough that an admixture of shale, or clay, or stone with the coal goes against the trade, and so they are generally very careful in this respect, and give very little trouble. Then, in slate quarries where large quantities of rubbish have to be removed, thousands of tons at a time falling into the quarries, it is a matter of calculation what shall be paid to the men by the quantity.

In some mines a combined system of payment is carried out. Thus, in the South Tamar Mine the tutwork is done at so much per running fathom, while in the case of the Carn Brea Mine that would not do at all by itself, but is combined with tributing. The tributer imagines from the appearance of the strings, perhaps, that if he advances a little further they will come together and produce more ore than is visible at the spot then in view, and so he works with a view to his getting a better chance of making wages, and is always on the look out for such appearances and chances. It is this which makes the system of tributing so useful. It brings in the experience, judgment, and acuteness of the men who have been working any length of time in a particular ground, to the mutual advantage of the tributer and the proprietor. He undertakes to work away a given area of the mine, called a pitch, consisting of so many fathoms in length and height, and take out all the ore he can; and for this he is to have so many shillings out of every pounds worth of ore. It is thus to his interest to examine carefully the rocks he passes through, to keep his eyes well open, and to carry in his memory all the places which he has observed as promising well; and it is equally good for the adventurers. But the system has drawbacks. It may, and does, sharpen the wits of the men, but that is a two-edged sword, which cuts both ways. The men imagine that if they conceal or keep the knowledge of favourable appearances to themselves it will be to their advantage in making their next bargain; and they consider that they are justified in so doing. Their morality, perhaps, is not of the highest grade, but human nature, after all, is the same down in a mine as at the surface. A careful manager must, therefore, be always on the alert to see that no such tricks are tried. The temptation, no doubt, is great, as it not unfrequently happens that when one tribute pitch is let at 15s., another at 1*l.*, and perhaps at no greater distance a third will be only 5s. This leads to the dishonest transfer of pieces of ore from the richer place to the poorer—a distinct robbery on the management of the mine, which has to be guarded against by the vigilance of the agent. Sometimes, when the men are paid by the quantity of material broken down, they are allowed, also, something on the ore obtained from it. When the ores are of the more precious metals special arrangements must be made to prevent the waste of the smallest particle of metallic material.

LECTURE XXI.—There are many kinds of open working which fairly come under the designation of mining, their methods and objects being similar. In the early days of mining metalliferous deposits were frequently attacked at starting on an outcrop with open workings. The first thing in such cases is to remove the overburden, as it is called, which consists generally of vegetable soil, of gravels and sands, or other alluvial deposits, and other material of a valueless character. The labour required is of a simple, unskilled kind, but it often happens that a large amount of prevision and contrivance on the part of the manager will be required. Taking, by way of illustration, a working at Stanton, in Derbyshire, for ironstone, a drawing of which in its condition some years ago was on the wall, Mr. SMYTH pointed out that the face of the working was 60 ft. in

length, and vast quantities [illegible] thrown down by shots put in at the surface. The iron ore, which *in situ* appeared in bands, with intervals of other but useless material, was picked out and stacked until it could be removed for conveyance to the smelters. At starting the work began on a hill side. The vegetable soil would be carefully removed if it existed in any quantity, and put aside, with a view of replacing it when the [illegible] fa[illegible]nough to admit of the excavation being filled in wi[illegible] the re[illegible]ase a stationary engine was erected at the surface, fro[illegible] whic[illegible]ined planes of rail were run down to the bottom of the workings. By t[illegible] means the ironstone is not only drawn up to the level of the engine, [illegible]t t[illegible]ttle or refuse is brought away from the face, and being tilted at [illegible]e top, a[illegible]caped out of the way, is afterwards roughly levelled for the rece[illegible]n of t[illegible]table soil. By this process, however, a large space has been [illegible]ally[illegible], And here I may take the opportunity of pointing out that a la[illegible]st[illegible]wn in arrangements of this sort between this country and others [illegible]opulated, and new countries like America, the necessity of remaki[illegible]d surface destroyed by excavations being hardly known in the l[illegible]in the former it is a duty incumbent on the engineer in almost all [illegible]sta[illegible] In many cases when a mine is commenced on a hill side with open work[illegible] it is necessary also to run an adit level to drain the superincumb[illegible]. The removal of the overlie in cases of this kind seldom offers any s[illegible]lties unless the material be of a very adhesive character, when it will [illegible]uir[illegible]pecial management. The removal of the overlie depends greatly [illegible]the p[illegible]ysical character and condition of the ground. Another sort of open w[illegible]r[illegible] what is called "pa[illegible]ching" in some districts, particularly in South Wa[illegible]heap way of getting ironstone, consisting simply of working away at t[illegible]side, and which becomes only a case of drawing away the material, ar[illegible]according as the work is done with a single stope or step, or a series[illegible]tter plan is usually adopted, as it allows of the employment of a grea[illegible]n[illegible] of men. In foreign quarrying the latter is the method usually adopt[illegible]ndeed, in our own slate districts of Wales, and where building stone is g[illegible]rge scale, a succession of stopes is indispensable.

Passing to the subject of stream-wo[illegible]s,[illegible]h are opened for gold in some countries and for tin in our own, it becomes a[illegible]imary question to known how to dispose of the alluvial stuff at the t[illegible]pposing we are dealing with a valley, and a stream running through it,[illegible]uestion is first how to get rid of the water. If we have the opportunity[illegible]ging down, and thus getting rid of the water, the case is much simplifie[illegible]ppose the case of a flat bottom, where there is no great fall for water, if we would remove the material as fast as it is dug out we must devise some [illegible]eans of disposing of the water. The most remarkable of these stream-wo[illegible]s in this country are those at Pentuan, in Cornwall, which occupy the whole v[illegible]ey for miles in length, and where a succession of steps are formed in the [illegible]ial ground which lies over the tin ore sought for. The bottom, or wha[illegible]lled the "shelf," is composed of killas, with occasional dykes of elvan, and steps are formed in the alluvial deposit by which a large number of men can work at once. In this case the natural stream of water running down the valley is so managed as to do the work of washing; and it is so utilised, by means of well-devised culverts, along which the water is conducted. Of course the process is much cheapened when it can be done by a natural stream, but othdrwise a steam-engine or a water-wheel may have to be brought into play. In the New World superficial deposits of auriferous sand and gravel of a valuable character exist sometimes to a great depth. At the Whitehaven lead, for instance, at Ballarat, the valuable detritus is 319 ft. in depth. In the operations necessary to work there it becomes necessary to turn the course of considerable streams; and to keep up communications between the higher and lower workings by means of arching in masonry; and to make culverts so that the water may flow down the workings under the waste material, which is got rid of by throwing it on the top of such culverts. In some instances roads have to be changed, to obtain leave for which in this country would take not a little both of time and money, while in California you may have only to arrange with your next neighbour, who most likely would be interested in the change as much as yourself. The cost of removing the overburden, if done by manual labour entirely, is very heavy, and particularly in new countries like California, where labour is dear. The Californians, to meet this difficulty, have introduced a system which they call "hydraulic mining." Water is brought from reservoirs or tanks by what are called "flumes" or aqueducts, which are placed at an elevation of 130 or 140 ft. above the auriferous gravel to be acted upon, and there will be a mass of from 120 to 160 ft. of gravel to be removed. The water thus conveyed passes into a large wooden tank, or "box" as the local term is. This box is provided with a valve, and from it the water is conveyed to the bottom of the working by means of a sheet-iron rivetted pipe from 8 to 14 in. in diameter, in the sides of which are apertures provided with slide-valves and union-joints, to which four or five flexible tubes or hose are attached, each ending in a nozzle of bronze 2½ to 3 in. in diameter. From these powerful jet streams are directed against the face of the working with a force which, it is said, can only be compared to that of ordnance, and where the supply of water is large, and the fall considerable, the effect is perfectly astonishing. The quantity of material dislodged by a single arrangement of this kind is greater than could be produced by a regiment of navvies, and its economy, therefore, is extremely great. Mr. J. A. Phillips, in his recent excellent work, entitled "Mining and Metallurgy of Gold and Silver," gives as an illustration of the amount of work which can be performed in a given time by hydraulic mining the results obtained at the Eureka claim, near San Juan, California, where the bed of "pay dirt" is about 135 ft. in depth. The upper portion of this deposit, to the depth of 70 ft., does not contain a large amount of gold, but is easily worked, whilst the lower portion, having a thickness of 65 ft., is much richer, but cemented together, and the work is, therefore, carried on under conditions of considerable difficulty. The [illegible]irt is reached by a bed

rock tunnel of great length, which costs on an average $8 per foot, and of which the total expense was $28,000. The works is carried on by means of four jets d'eau, discharging together about 208 gallons per second, or 12,500 gallons per minute, under a pressure of 140 ft. The whole of the operations are conducted by four men, and at the expiration of 10 working days the washing down of fresh earth is suspended, and the sluices cleared up. In these 10 days 36·500 cubic yards of gavel are worked over. All that the men have to do is to direct the nozzles, and no human labour can be placed in comparison with the system, either in effect or economy. Mr. Phillips gives an interesting statement of the cost of these 10 days, as follows:—Cost of water, $1000; labour, $173; sundries, $100: total, $1273. The average quantity of gold obtained in this period is worth $6000. This is sufficient to give an idea of this admirable method of removing the over burden when it is composed of loose material; but when it is more adhesive charges of powder must be used.

There is another species of open work to which I have already alluded, in which the whole material might be valuable, as in the case of building stone and slate. In opening quarries of this kind care must be taken at starting that the works shall be well drained, and that there shall be a free exit for the rubbish, which is often enormous in quantity. The next question will be whether the material shall be wrought in one face or several. These are points which will be influenced decisively by local circumstances. In cases of material in which that part only has to be removed through which metallic particles are disseminated irregularly the workings will inevitably lack regularity. In England the most remarkable case of this kind is presented by the great open workings for tin at Carclaze, near St, Austell. A great amount of mineral has been removed in following the valuable tinstuff, and vast cavities have been opened to the height of the hill top, and ¾ mile in breadth, and it presents a most interesting example of excavations on a gigantic scale. Smaller examples are not uncommon where the killas or schistose rocks of a particular kind in which a little tin is found have been removed, leaving the rubbish behind, and thus a good deal of tin ore has been obtained at an extremely small cost of carriage. On the Continent there are remarkable instances of this class of workings at Altenberg, Ehrenstein, and at Staggenwald, in Bohemia. Scandinavia, too, has some valuable deposits of this kind, which have led to the famous open workings at Dannemora in Sweden, at Arundal in Norway, and at Fahlun near Stockholm, at which latter place vast quantities of copper ore having been extracted by open quarrying, they are now proceeding by subterranean excavation. In the same way, at the Parys and Mona Mines, in the Isle of Man, the nature of the occurrence of the copper ore enables the work to be carried on in a manner similar to that practised at Fahlun.

After a time, however, it will probably become a question as to whether the mine shall cease to be carried on as an open cutting. At a well-known mine in Saxony, where they had to work upon a dome of granite enclosed in schistose rocks, it was considered better, even when the excavations were very deep, to hold on as an open working; the men were better overlooked, and the application of hydraulic machinery could be effected in a cheaper way. But when the overlie gets to be 100 or 150 ft. in height it becomes a serious question as regards the safety of the workmen. There is a limit beyond which such vast open workings are no longer compatible with safety, and that limit depends upon the hardness and dip of the material; and even in slate quarries there is a constant danger of falls, to the great risk of the men working below.

There is no more important mining industry in our own country than slate quarrying. An intelligent Prussian engineer has lately given some statistics on the subject, and he states that in France 188,000 tons of slate (the weight being that of saleable material) are annually obtained; in Germany, 78,000; in Belgium, 25,000; in Scotland, 12,000; in England, 60,000; and in Wales, 470,000 tons. Thus, it will be seen that slate quarrying is a branch of mining operations to which a great deal of skill, as well as capital, must be brought. In the Geological Lectures a good deal of attention has been given to the cleavage, as well as to the deposit of the beds of slate, and you will remember that there is a considerable amount of regularity to be found in those particulars. Thus, a particular plane of cleavage will be found to stretch through a whole line of country, with scarcely any deviation. And where the original line of deposition is not visible the miners must be careful not to take the plane of cleavage to be the line of the beds. This is a matter of great importance, because it is the plane of cleavage which is looked to first by the workmen, who work parallel to those planes rather than parallel to the beds, and thus regulate the form of the quarry. There may be whole mountains of slatey rock which will not produce a ton of

slate commercially valuable; and the great thing is to discover good slate. The quality even of commercial slate varies very much, and sometimes large beds which look well turn out, when worked, to be inferior to other beds which do not put on nearly so promising an appearance. The Welsh slates occur principally in the Lower Silurian deposits, which produce the blue slates got in the neighbourhood of Festiniog, and in the Cambrian rocks, which commence in the neighbourhood of Bangor, and run in a north and south line towards the lakes of Llanberis. The Cambrian division have their cleavage almost vertical, while in the Festiniog district they dip at a moderate angle (say, about 30°), the bedding being excessively confused and contorted, dipping at a rather higher angle than the cleavage. The most magnificent slate quarries in the world are at Penryhn, near Bangor. The face of the working is above 1000 feet in height, cut into a series of semicircular stages, each about 54 ft. in width, and each having a different set of men. As each working goes on step by step, and simultaneously, the whole face is gradually worked down, the whole forming a vast amphitheatre. A series of inclined planes are arranged, by which the material is conveyed to the places where they are split, and other places where the refuse is put. This plan is the best that can be devised for employing with effect a large number of men.

The next point is to secure the means not only of sending down the slate to the central places, but to remove the rubbish to be tipped over on such a portion of the mountain as there is good reason to believe will not yield good slate. This is important, because these quarries are often opened without consideration for the future, and thousands and tens of thousands of tons of rubbish have been tipped where it was afterwards found the slate was good, and which could not, therefore, be obtained except by removing this artificial overlay, or by underground mining. Careful arrangements must also be made to prevent unnecessary breakage of the slate by dropping it too far, or farther than is necessary, after it has been quarried. This is done by slides and various cognate contrivances, so as to let down the material from the face of the rock whence it is got to the level below. The quarrymen are hardy fellows, of unflinching courage, who suspend themselves from the heights above, or who work on narrow ledges, from which a fall would be fatal, but they seldom have any accidents, and seem not to know what giddiness or fear are. Sometimes, however, vast masses of the rock will break away, and fall like an avalanche, overwhelming all below. There is, however, generally sufficient warning to permit the escape of the workmen, but the steps below are in such cases destroyed, and the regularity of the quarry greatly depreciated. In the southern parts of these slate districts a practice obtains of following the slate vertically downwards until the face is often 200 or 300 ft. from the top, and if the rock be jointy there is a constant tendency of large masses to fall in this avalanche-like way, and the flaws not being visible at the top, which is usually covered, although perhaps very thinly, with some sort of overlie, this danger is very considerable. The sort of warnings which the men get are, perhaps, the fall of a few small stones, as the tottering mass begins to incline. This attracts attention enough to permit them to escape, because they are aware of the character of the danger, but there is neither time nor possibility of means to avert the catastrophe under such circumstances. I have known cases in which masses have fallen which have filled up an entire quarry to three-fourths of its height, and so stopped the working for many years. This arises entirely from the faulty principle on which the quarries are laid out. In all such cases the adoption of the stope arrangements, like that of the Penrhyn Quarries for instance, would have prevented the accidents, and where falls, if inevitable, would have been moderate in extent, and thus neither have imperilled the safety of the workmen nor the existence of the quarry. In laying out the workings of a quarry it is, in reference to this particular danger of falls, important to know whether the cleavage faces you or goes away from you. If the face is towards us the step must be broader to prevent falls, and then there will be some advantage in the fact that the slate when broken away will slide down to the bottom of the quarry, to be further treated and fitted for the market. It sometimes occurs that the question of a quarry paying or not paying depends upon this very point, and the necessity has happened for changing the place and beginning again. Proceedings of this kind, however, should be avoided by careful examination and study of each individual case, as the patience of shareholders is gradually worn away when it is found that at great expense the mountain side has been attacked, and satisfactory results have not followed. There are many good quarries on which from 30,000*l.* to 50,000*l.* was expended before there was any return.